DISPERSION OF EFFLUENT IN DELAWARE RIVER FROM NEW JERSEY ZINC COMPANY PLANT

Hydraulic Model Investigation

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PREFACE

The New Jersey Zinc Company, 160 Front Street, New York 38, New York, requested the U. S. Army Engineer Waterways Experiment Station to conduct the studies reported herein in a letter dated 7 December 1956. The studies were conducted in the existing Delaware River model, authority to perform the tests having been granted by the U. S. Army Engineer District, Philadelphia, CE, and by the Office, Chief of Engineers. The New Jersey Zinc Company paid all costs in connection with the model study and with the preparation and publication of this report.

The study was conducted in the Estuaries Section of the Hydraulics Division of the Waterways Experiment Station during the period 14 December 1956 to 9 January 1957. Engineers of the Waterways Experiment Station actively connected with the study were: Messrs. E. P. Fortson, Jr., Chief, Hydraulics Division; G. B. Fenwick, Chief, Rivers and Harbors Branch; H. B. Simmons, Chief, Estuaries Section; W. H. Bobb, Project Chief; and C. J. Huval. The New Jersey Zinc Company was represented by Messrs. Blan W. Hale and Bradford C. Hafford, company employees; Mr. F. S. Friel of Albright and Friel, Inc., Consulting Engineers; and Prof. L. J. Hooper of Worcester Polytechnic Institute. These company representatives inspected the model before the testing program was begun, and several of them returned to the Waterways Experiment Station while the tests were in progress to observe the techniques and procedures employed, review the results of model tests, and plan additional tests.

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SUMMARY

An existing model of the Delaware River was used to study plans for improving the dispersion of effluent in the Delaware River from the Gloucester City plant of the New Jersey Zinc Co. The present method of discharging plant waste into an abandoned slip with a low bulkhead at its riverward end has resulted in higher concentrations of plant effluent in small embayments and pockets along the New Jersey shore in the vicinity of the plant than in the channel proper. Proposed means for improving effluent dispersion are construction of a pipeline to transport the effluent to an outfall located on the bottom of the river between the navigation channel and the shore. The purpose of the model tests was to determine whether more rapid dispersion of the effluent and elimination of areas of high concentration could be expected from the proposed changes and the effects of these changes on effluent concentrations throughout the estuary as a whole. Of primary interest was determination of the upstream limit of intrusion of plant effluent for various conditions of river discharge, rate of plant discharge, and location of pipeline outfall.

It is believed that the following general conclusions can be drawn from the results of the model tests:

a. River discharge appears to be the dominant factor controlling effluent concentrations and extent of upstream intrusion.

b. Reductions in maximum effluent concentrations in areas near the plant site can probably be effected by location of the outfall so as to promote rapid mixing of the effluent with the river water. An accurate determination of the extent of such reductions will require work in a larger model. The exact location of the outfall would have little if any effect on effluent concentrations throughout the river as a whole or on the extent of upstream intrusion of the effluent.

c. Intermittent rather than continuous release of effluent would not significantly reduce concentrations or the extent of upstream intrusion of the effluent.

d. An increase in plant effluent discharge from 6 to 12 mgd would essentially double effluent concentrations at equivalent locations along the river, all other conditions being equal, but the increased effluent discharge would not cause a significant increase in the extent of upstream intrusion of the effluent.

DISPERSION OF EFFLUENT IN DELAWARE RIVER FROM NEW JERSEY ZINC COMPANY PLANT

Hydraulic Model Investigation

PART I: INTRODUCTION

The Problem and Purpose of Tests

1. The Gloucester City Plant of the New Jersey Zinc Company, located on the New Jersey shore of the Delaware River east of Philadelphia, is presently discharging plant waste into an abandoned slip adjacent to the plant site (outfall A on plate 2). A bulkhead constructed to el +2.0 ft mlw across the river end of the slip creates a partial retention basin. Most of the waste, which is heavier than river water, passes from the slip into the river during the ebb portion of the tidal cycle, but the bulkhead has deteriorated to such extent that a considerable part of the effluent escapes throughout the remainder of the tidal cycle. Current velocities adjacent to the shore line in the vicinity of the slip are low, and the plant effluent is not being rapidly dispersed throughout the cross section of the river. As a result, concentrations of plant effluent in small embayments and pockets along the New Jersey shore in the vicinity of the plant are somewhat higher than concentrations in the channel proper.

2. The New Jersey Zinc Company is studying means for improving effluent dispersion by constructing a pipeline to transport the effluent to an outfall located on the bottom of the river between the navigation channel and the shore. The purpose of the model tests was to determine whether more rapid dispersion of the effluent and elimination of areas of high concentration could be expected from the proposed changes, and the effects of the proposed changes on effluent concentrations throughout the estuary as a whole. Of primary interest was the determination of the upstream limit of intrusion of plant effluent for various conditions of river discharge, rate of plant discharge, and location of pipeline outfall.

Scope of Tests

3. It was agreed at the initiation of the investigation that the existing Delaware River model offered the best means for determining the effects of the various schemes being considered on effluent concentrations throughout the estuary as a whole, while study in a large-scale model will probably be required for detailed analysis of dispersion of the effluent in the immediate vicinity of the plant site and for design of the outfall system. It is contemplated that the large-scale model for this latter portion of the study will be constructed at the Worcester Polytechnic Institute.

The Model

4. The area reproduced in the Delaware River model is shown on plate 1. A description of the model and appurtenances, and details of the model adjustment and verification are presented in Waterways Experiment Station Technical Memorandum No. 2-337, Delaware River Model Study, Report No. 1, dated May 1956, and are not included in this report. The above-mentioned report also discusses the model-to-prototype scale relationships for time, velocity, discharge, etc., which are derived by the Froudian relationships from the horizontal scale of 1:1000 and the vertical scale of 1:100. The scale relationship for concentration and specific gravity of the effluent, applicable to the results of tests reported herein, is 1:1.

Conditions Tested

5. The New Jersey Zinc Company plant effluent has an average specific gravity of about 1.003, an average concentration of the order of 6800 parts per million, and is presently discharged continuously into the abandoned slip (outfall A, plate 2) at the rate of about 6 mgd. Mean tide heights vary from +0.5 to +6.5 ft mlw in the adjacent reach of the Delaware River, and the major portion of the effluent flows from the

slip when the water-surface elevation in the river falls below +2.0 mlw, the height of the bulkhead at the slip entrance. However, as stated earlier, because of the deterioration of this sheet piling bulkhead, and the difference in density of the effluent and river water, some of the effluent is discharged into the river throughout the tidal cycle.

6. The proposed pipeline is to extend from the edge of the slip toward the navigation channel along an alignment perpendicular to the slip bulkhead. Proposed outfall B is located 350 ft from the bulkhead, and proposed outfall C is located on the edge of the Gloucester Anchorage 700 ft from the bulkhead (see plate 2). The depth at outfall B is approximately 17 ft below mlw, and that at outfall C is approximately 24 ft below mlw.

7. Tests were made for river discharges of 12,000, 8000, 3400, and 2400 cfs in order to determine the effects of river discharge on effluent dispersion. The river discharges for all previously reported tests in the Delaware River model have been expressed in terms of cubic feet per second at and including the Schuylkill River. The New Jersey Zinc Company is located upstream from the mouth of the Schuylkill; therefore, the river discharges referred to herein represent only the Delaware discharge at Trenton. The maximum flow tested (12,000 cfs) is approximately equal to the mean Delaware discharge at Trenton. The 8000-cfs flow is an arbitrary intermediate value, while the two lower flows represent minimum controlled discharges at Trenton with the Incodel Plan completed to stages with and without the Wallpack Bend or Tocks Island Reservoirs. Only flows equal to or less than mean were tested since it was desired to determine the extent of plant effluent intrusion and degree of dispersion upstream from the outfall and it was known that maximum upstream intrusion would occur for the lower river discharges.

8. The effects of increasing the plant effluent discharge rate from 6 to 12 mgd were also investigated. The effects of such an increase were determined for river discharges of 8000 and 3400 cfs, since the increase in effluent discharge rate is not contemplated until completion of Wallpack Bend Dam or the Tocks Island Dam along the main branch of the Delaware River, either of which will increase the minimum flow at

Trenton from 2400 cfs to 3400 cfs. An intermittent type of effluent release, or release only within a certain portion of the tidal cycle, was also investigated to determine if any benefits could be derived from that type release. The portion of the tidal cycle during which the effluent was released was of six hours duration and included the last hour of flood current at the plant site and the subsequent five hours of ebb current.

9. Because of the proximity of Big Timber Creek (see location map, plate 2), it was considered necessary to reproduce its fresh-water discharge. The mean fresh-water discharge of Big Timber Creek was computed to be 82 cfs, from data supplied by Mr. F. S. Friel, and this discharge was reproduced during all tests reported herein. Certain model shore line features along both sides of the river in the vicinity of the plant were also altered to bring shore line conditions up to date, since it was felt that such features might affect the rate of dispersion of the plant effluent.

PART II: TEST PROCEDURE AND DATA OBTAINED

Test Procedure

Selection of tracer

10. A tracer was needed that would permit accurate detection of the plant effluent throughout the course of the model tests. The average concentration (6800 ppm) and the average specific gravity (1.003) of the plant effluent were both known, and consideration of these and other physical characteristics of the effluent showed that its concentration could be simulated in the model by means of methylene blue chloride dye, and that the specific gravity of the model effluent could be adjusted to that of the prototype by addition of sodium chloride. Since concentrations of methylene blue chloride can be determined photometrically, and concentrations of sodium chloride can be determined by titration with silver nitrate, either or both of these materials could be used as tracers to detect the effluent accurately throughout the course of model tests.

11. The use of sodium chloride as a tracer required that the model be operated with fresh water throughout, instead of with salt water in Delaware Bay and the lower Delaware River as is used in normal operation, to insure that sodium chloride detected at any point in the model came from the plant effluent and not from the lower reaches of the model. Operation with fresh water throughout the model also improves the accuracy of photometric determination of dye concentrations, since the model water remains clean for a considerable period of time (which it does not do when salt water is used), thus eliminating the need for taking spectrophotometer readings of all samples at three wave lengths in order to compute light extinction attributable to foreign matter in the samples. Use of fresh water throughout the model was considered permissible since no measurable effects of density on current velocities and current distributions occur in the region of the river adjacent to and upstream from the plant site, even for conditions that permit salt-water intrusion into this part of the estuary.

12. Accordingly the model was filled with only fresh water and an

exploratory test was made in which the concentration of the effluent was simulated by a 6800-ppm concentration of methylene blue chloride and the specific gravity of the effluent was adjusted to 1.003 at 20 C by addition of sodium chloride. The effluent was released in the slip at a rate equivalent to 6 mgd in the prototype to simulate the existing method of disposal, and samples were obtained from the model at numerous points and analyzed for dye concentration by means of a Beckman model DU spectrophotometer and for sodium chloride concentration by titration.

13. The results of the exploratory test showed that the amount of sodium chloride being introduced was insufficient to permit accurate measurement at distances greater than three or four miles upstream or downstream from the plant site. Since it was not possible to increase the amount of sodium chloride introduced into the model without increasing the specific gravity of the plant effluent, which would probably have resulted in an erroneous dispersion rate in the vicinity of the outfall, it was decided that sodium chloride could not be used as a tracer. On the other hand, concentrations of methylene blue chloride contained in samples obtained from the model were much greater than necessary for accurate measurement by means of the spectrophotometer; in fact, the sample concentrations were so great that most samples had to be diluted with distilled water prior to analysis. It was decided that methylene blue chloride would be used as the tracer; however, since dilution of numerous samples is very time consuming, it was also decided that dye concentrations for all formal tests would be fixed at about one-tenth of the prototype concentration (about 680 ppm instead of 6800 ppm) so that the samples could be analyzed without dilution. It is interesting that the results of dye analyses (expressed in per cent of initial concentration) made during the exploratory tests, which involved an initial concentration of 6800 ppm, were in almost exact agreement with the results of the first formal test which involved an initial concentration of 680 ppm, or about one-tenth the prototype concentration.

Preparation and injection of effluent

14. The effluent for each test was prepared a day in advance by adding the weighed amount of dye required to provide the desired

concentration to the quantity of water needed for the test. Some difficulties were encountered in getting all of the dye into solution; therefore, samples were obtained from the effluent container prior to and at regular intervals throughout each test, and the initial concentration of the effluent was assumed to be equal to the average of these samples. The specific gravity of the effluent was adjusted to 1.003 after addition and mixing of the dye, since the dye tends to go into solution at a faster rate in fresh water than in water containing sodium chloride.

Operation of model

15. The model was operated for conditions of mean tide for all tests reported herein. After operation of the tide generator was started, the inflow weirs were adjusted to introduce the upland discharges of the Delaware River and all tributaries as prescribed for the particular test involved. Operation of the model was continued for several tidal cycles prior to release of the effluent to permit checking of weir settings and to eliminate the possibility of any minor errors associated with the beginning of operation. Each test was assumed to start at the time injection of effluent was started, and its duration is expressed in tidal cycles after start of effluent injection.

Data Obtained

Continuous samples

16. From the beginning of each test, samples were obtained at mid-depth at several selected mid-channel stations at intervals of one to five tidal cycles and at the time of local high- or low-water slack of the current. A running plot of these data was maintained to show variations in effluent concentration with time. It was known from previous tests of a similar nature that effluent concentrations at any station would increase at a steadily decreasing rate until a stable concentration was reached for the conditions being tested; it was also known that the effluent would migrate upstream at a steadily decreasing rate until a stable length of intrusion would obtain for the conditions being tested. Therefore, the purpose of the continuous sampling during the transitory

period of effluent concentration and upstream migration was to determine the length of time required for stability to be reached for each test condition.

Detailed sampling

17. When the results of the continuous sampling described above indicated that stability of effluent concentrations and intrusion had been reached,* samples were obtained at numerous stations at both high- and low-water slack of the current to show the exact extent of intrusion of the effluent as well as the concentrations along the channel. These samples were obtained at 5000-ft intervals from about the plant site (channel station 40+000) to the upstream limit of intrusion, at 10,000-ft intervals from about the plant site downstream to station 80+000, and at channel stations 100+000, 120+000, 140+000, and 180+000. The locations of all sampling stations are shown on plate 1. In addition to the samples from these mid-channel stations, samples were obtained at five local stations (stations 1-5, plate 2) near the plant site during the same sampling operation in which the high-water slack samples were obtained. Although it was recognized that local concentrations of effluent could not be considered accurate in a quantitative sense, it was felt that such samples would provide a qualitative indication of the relative effluent concentrations to be expected locally for each of the conditions tested.

Presentation of test data

18. All test data relative to effluent concentrations presented in this report are expressed in terms of per cent of the initial concentration of the effluent being injected. As described in paragraph 14, the initial concentration of effluent for each test was determined by averaging the results of analyses of samples obtained from the effluent container prior to and at regular intervals throughout each test. The concentrations of all samples obtained during each test were divided by the initial concentration to determine their values in terms of per cent of

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* Certain of the tests were not continued to stability, as will be discussed later in this report, since the testing time required for stability to be reached for extremely low flows made such tests appear unreasonable.

initial concentration. Although the initial concentrations were not exactly the same for all tests (see table 1), expression of the results in terms of per cent of initial concentration makes the results of all tests directly comparable to each other.

PART III: MODEL TESTS AND RESULTS

Objectives of Model Tests

19. A total of nine tests were made in the model, and the conditions for each are summarized in table 1. The tests were designed to provide the following information: (a) the effects of river discharge on effluent concentrations and extent of upstream intrusion, especially in the critical reach of the river at and upstream from the plant site (tests 1-4); (b) the benefits, if any, that would be derived from changing the existing continuous release of effluent to an intermittent release during certain prescribed hours of the tidal cycle (tests 3 and 8); (c) the relative merits of proposed outfall locations B and C (plate 2) as compared to the existing method for disposal of the effluent (tests 3, 4, 7, and 9); (d) the effects of doubling the plant output (increase in effluent discharge from 6 to 12 mgd) on effluent concentrations and extent of upstream intrusion (tests 2, 3, 5, and 6); and (e) the maximum effluent concentrations and extent of upstream intrusion that would occur for conditions of the lowest possible river discharge. The detailed results of all model tests are presented in tables 2, 3, and 4.

Effects of River Discharge

20. The test conditions for tests 1-4, conducted to determine the effects of river discharge on effluent concentrations and extent of upstream intrusion, were identical except that the river discharge at Trenton was varied: 12,000 cfs for test 1, 8000 cfs for test 2, 3400 cfs for test 3, and 2400 cfs for test 4. (The discharges of all major tributaries were also varied in accordance with variations in the Trenton discharge.) Outfall C (plate 2) was used for this series of tests, since it was believed that this outfall would provide the best possible conditions in the vicinity of the plant.

21. The results of the continuous sampling during tests 1-4 are presented on plate 3, and the results of detailed sampling to show final

effluent concentrations and extent of intrusion are presented on plate 4. The curves presented on these plates were initially prepared on work sheets on which the exact values of all samples obtained from the model were plotted, and these curves represent the best fit to all plotted points. To avoid confusion, the points were omitted from plates included in this report; however, the values of all samples used in construction of the smooth curves are contained in tables 2 and 3 and the reader may plot them on the plates if he wishes.

22. Examination of the results of continuous sampling during tests 1 and 2 (plate 3) indicates that effluent concentrations were stable by the end of the tests at and upstream from the plant site. Similar data for test 3 (plate 3) indicate that stability of effluent concentration was almost attained at station -35+000, but that concentrations were still increasing at all other sampling stations. Data for test 4 (plate 3) show that stability was essentially reached at station -60+000, but that concentrations were still increasing at a fairly rapid rate at all other sampling stations. Tests 3 and 4 were terminated at the end of 120 tidal cycles (equivalent to about two months in nature) because of the improbability of the continuation of such low flows for a longer period of time, and also because of the difficulties and cost of continuing the model tests for a greater period of time (the actual duration of a 120-cycle test was about 15 hours, not including time required to start the model and analyze the final samples).

23. Effluent concentrations observed on the channel center line at high- and low-water slack of the current at the end of tests 1-4 are presented on the bottom portion of plate 4. These data indicate that the maximum effluent concentration was located about 20,000 ft upstream from the plant site at high-water slack and about 20,000 ft downstream at low-water slack, the maximum concentrations at these times being approximately equal. The maximum effluent concentration for test 1 was 0.050 per cent of the initial concentration, that for test 2 was 0.075 per cent, that for test 3 was 0.165 per cent, and that for test 4 was 0.200 per cent. It is interesting to note that maximum effluent concentrations observed near the plant site for these tests are in fair

agreement with those computed by the ratio of plant effluent discharge to river discharge, assuming complete mixing of the effluent. Computed maximum concentrations for conditions of the model tests are 0.077 per cent for test 1, 0.116 per cent for test 2, 0.270 per cent for test 3, and 0.386 per cent for test 4. The observed and computed maximum concentrations for tests 1 and 2 were in fairly good agreement, since the model tests were continued until stability of effluent concentrations was essentially reached. The computed maximum concentrations for conditions of tests 3 and 4 were appreciably greater than those observed; however, concentrations in the model were increasing steadily at the termination of these tests, and it seems likely that they would have approached the computed maxima if the tests had been continued to stability.

24. The extent of upstream intrusion of an effluent concentration equal to 0.01 per cent of the initial concentration at high-water slack was to about station -10+000 for test 1, station -22+000 for test 2, station -60+000 for test 3, and station -80+000 for test 4. Concentrations at low-water slack for all tests were 30,000 to 35,000 ft downstream from the location of equivalent concentrations at high-water slack, which provides a rough index to the tidal excursion length in this region of the river. The shapes of the curves presented on plate 4, as well as the results of continuous sampling presented on plate 3, indicate that stable effluent concentrations were not attained downstream from the plant site for conditions of any of the model tests, although downstream stability was almost attained for test 1. From a theoretical viewpoint, average concentrations at all channel stations downstream from the plant site should be equal to those at the plant site at the time of stability, provided that no additional fresh water entered the system at one or more downstream points to further dilute the effluent. Actually, the Schuylkill River discharges into the Delaware River at about station 60, so that additional fresh water was available for further dilution of the effluent. From a practical viewpoint, it appears that downstream stability was essentially attained for test 1, almost attained for test 2, and far from attained for tests 3 and 4 as would be expected.

25. The results of sampling at the five local stations (stations

1-5, plate 2) for tests 1-4 are presented in table 4. These samples were obtained during the high-water slack sampling operation mentioned in paragraph 23. It will be noted that effluent concentrations at the local stations vary inversely with river discharge, the highest concentrations having been noted for test 4. The observed concentrations for tests 1 and 2 are probably representative of the maxima that could be expected for the river discharges reproduced for these tests, but the observed concentrations for tests 3 and 4 would have increased if these tests had been continued to stability.

Effects of Mode of Plant Discharge

26. The effects of a continuous versus an intermittent release of the plant effluent on effluent concentrations and extent of upstream intrusion can be determined by comparison of the results of tests 3 and 8. Both tests involved outfall C and a river discharge of 3400 cfs. The plant effluent was discharged continuously during test 3, but during test 8 it was discharged only during the 6-hr period between hours 1 and 7 of the tidal cycle; this period encompasses the last hour of flood current and the first five hours of ebb current at the plant site.

27. The results of continuous sampling during test 8 are presented on plate 5 and should be compared directly to similar data for test 3 on plate 3. Such comparison indicates no significant differences between the two tests except that effluent concentrations at the end of test 8 were slightly higher at stations located downstream from the plant site and slightly lower at stations located upstream. This effect may be seen more clearly on the upper portion of plate 4, which presents a comparison of the final samples obtained at termination of the two tests. It will be noted that the effluent concentration curves for test 8 are displaced slightly in a downstream direction from those of test 3.

28. A comparison of the effluent concentrations of samples obtained at the five local stations for tests 3 and 8 is presented in table 4. No significant difference in effluent concentrations at the local stations is apparent between continuous and intermittent release

conditions. Concentrations at stations 1, 2, and 4 were slightly greater for test 3, while concentrations at stations 3 and 5 were slightly greater for test 8.

Effects of Location of Outfall

29. The three outfall locations investigated (A, B, and C) are shown on plate 2 and are described in paragraphs 5 and 6. The effects of the outfall locations on effluent concentrations and extent of upstream intrusion can be determined from comparison of the results of the following tests: tests 3 and 9 were identical except that test 3 involved outfall C and test 9 involved outfall B; tests 4 and 7 were identical except that test 4 involved outfall C and test 7 involved outfall A (test 7 was run for 240 tidal cycles, but data were obtained at a few stations at the end of cycle 120 for comparison with the results of test 4).

30. The results of continuous sampling for tests 9 and 7 are presented on plates 5 and 6, respectively, and should be compared directly to similar data on plate 3 for tests 3 and 4. Such comparison indicates no appreciable differences between the results of tests 3 and 9 and tests 4 and 7 with respect to rate of increase of effluent concentration at the various stations. For example, effluent concentrations at tidal cycle 120 of test 7 were almost identical with those at the end of test 4 at all stations.

31. Comparisons of detailed measurements of effluent concentration along the channel center line at the termination of tests 3 and 9 and tests 4 and 7 are presented on plate 7. Data presented for test 7 include observations made at the end of tidal cycle 120, for comparison with the results of test 4, as well as observations made at the termination of the test (tidal cycle 240). The curves presented on this plate show no appreciable differences in effluent concentrations or extent of upstream intrusion resulting from release of the effluent at the various outfall locations.

32. The results of samples obtained at local stations 1-5 (table 4) indicate that, in general, outfall C resulted in lesser concentrations

than did outfalls B and A (test 3 compared to test 9 and test 4 compared to test 7). It is pointed out that observed concentrations at the five local stations for tests 4 and 7 are not directly comparable, since data presented in table 4 for test 7 were obtained at tidal cycle 240 instead of tidal cycle 120. Through an oversight, no samples were obtained at these stations during tidal cycle 120 of test 7.

Effects of Doubling Plant Discharge

33. The effects of doubling the plant discharge of effluent (increase from 6 to 12 mgd) on effluent concentrations and extent of upstream intrusion may be determined from comparisons of the results of tests 2 and 5 and tests 3 and 6. River discharges at Trenton were 8000 cfs for tests 2 and 5 and 3400 cfs for tests 3 and 6. Tests 2 and 3 involved an effluent discharge of 6 mgd, while tests 5 and 6 involved an effluent discharge of 12 mgd. A continuous discharge of effluent from outfall C was used for all tests in this series.

34. The results of continuous sampling for tests 5 and 6 are presented on plate 5 and should be compared directly to similar data for tests 2 and 3 on plate 3. Such comparisons indicate that effluent concentrations at all stations for tests 5 and 6 were approximately double the equivalent concentrations for tests 2 and 3. In evaluating the maximum effluent concentrations observed during these tests, it should be remembered that the results of tests 2 and 5 represent essentially stable conditions at and upstream from the plant site at termination of these tests, while effluent concentrations had not reached stability at any stations at the termination of tests 3 and 6.

35. Comparisons of final sampling at the termination of tests 2 and 5 and tests 3 and 6 are presented on plate 8. These comparisons indicate that doubling the effluent discharge essentially doubled effluent concentrations throughout the region of the river in which samples were obtained. However, the effluent distribution curves presented on plate 8 show that the extent of upstream intrusion of the effluent would not be increased appreciably, if at all, as a result of increasing the plant

output. It appears that the river discharge is the dominant factor in the control of the upstream limit of intrusion, and while effluent concentrations would be essentially doubled at all points between the upstream limit of intrusion and the plant site, the limit of intrusion would not be changed appreciably.

36. Comparisons of samples obtained at the five local stations for tests 2 and 5 and tests 3 and 6 are presented in table 4. These data also indicate that effluent concentrations for test 5 were essentially double those of test 2, while effluent concentrations for test 6 were about double those of test 3. Effluent concentrations for tests 2 and 5 are considered representative of stable conditions, while those for tests 3 and 6 do not represent stable conditions since concentrations were still increasing at the termination of these tests.

Maximum Concentrations of Effluent

37. The conditions of test 7, which included the existing method for disposal of the plant effluent and which represented the worst possible condition of river discharge to be expected in nature (a sustained flow of 2400 cfs for a 4-month period), were used to determine maximum effluent concentrations and extent of upstream intrusion that might be expected if such a discharge condition should occur. The results of continuous sampling for this test are presented on plate 6 and the results of final sampling (tidal cycle 240) are presented on the upper portion of plate 7.

38. Plate 6 indicates that the 4-month period covered by the test was not sufficient to permit effluent concentrations at and upstream from the plant site to stabilize. Effluent concentrations appear to have been approaching stability at stations -85+000, -60+000, and -35+000; however, concentrations at stations farther downstream were still increasing steadily at termination of the test. The curves on plate 7 indicate that the maximum concentration of effluent near the plant site was about 0.25 per cent of the initial concentration, as compared to a computed maximum (based on ratio of plant discharge to river discharge) of 0.386 per cent

of the initial concentration. Although effluent concentrations would have increased at most stations if the test had been continued, the probable occurrence of a sustained low flow of the magnitude and duration of that used for the test is very remote. It therefore appears that the final results of test 7 are representative of the extreme concentrations and extent of upstream influence attributable to present operation of this plant.

PART IV: CONCLUSIONS

39. No attempt is made in this report to evaluate the results of model tests in terms of their effects in the prototype, since such evaluation will involve the chemical as well as the physical properties of the effluent, the constituents of the river water with which the effluent is mixed, and many other factors. Instead, the results of the model tests are expressed in terms that can be readily employed by those concerned with subsequent application of model data to the prototype problems involved.

40. It is believed that the following general conclusions can be drawn from the results of model tests reported herein:

a. River discharge appears to be the dominant factor controlling effluent concentrations and extent of upstream intrusion, since both effluent concentrations at given points and the upstream extent of effluent intrusion varied inversely with river discharge.

b. Reductions in maximum effluent concentrations in areas near the plant site can probably be effected by location of the outfall so as to promote rapid mixing of the effluent with the river water. An accurate determination of the extent of such reductions will require work in a larger model. The exact location of the outfall would have little if any effect on effluent concentrations throughout the river as a whole or on the extent of upstream intrusion of the effluent.

c. Intermittent rather than continuous release of effluent would not significantly reduce concentrations or the extent of upstream intrusion of the effluent.

d. An increase in plant effluent discharge from 6 to 12 mgd would essentially double effluent concentrations at equivalent locations along the river, all other conditions being equal, but the increased effluent discharge would not cause a significant increase in the extent of upstream intrusion of the effluent.

e. The results of test 7 are probably representative of the highest possible effluent concentrations that can result from the present method and rate of discharge into the Delaware River from the Gloucester Plant of the New Jersey Zinc Co.

Table 1

Summary of Test Conditions

Test Number	River Discharge cfs	Outfall Point	Effluent Discharge* mgd	Effluent Discharge* cfs	Dye in Effluent ppm
1	12,000	C	6	9.28	493
2	8,000	C	6	9.28	685
3	3,400	C	6	9.28	654
4	2,400	C	6	9.28	637
5	8,000	C	12	18.56	723
6	3,400	C	12	18.56	692
7	2,400	A	6	9.28	663
8	3,400	C	6	18.56	743
9	3,400	B	6	9.28	880

Note: See plate 2 for location of outfall points.

* Plant effluent was discharged at a continuous rate for all tests except test 8 in which it was discharged during that portion of the tidal cycle between hours 1 and 7 (see paragraph 26).

Table 2

Results of Continuous Observations

Dye Concentrations in Per Cent of Plant Effluent Concentration

Tidal Cycle	Low-water Slack Sta 100	High-water Slack Sta 100	Sta 20	Sta -10	Sta -35	Sta -60	Sta -85
			Test 1				
9	0.021	-----	-----	-----			
10	0.026	0.001	-----	0.000			
11	0.032	0.005	-----	0.000			
12	0.033	0.004	-----	0.007			
13	0.032	0.008	0.028	0.002			
14	0.048	0.013	-----	-----			
15	0.043	-----	0.033	0.001			
16	0.039	0.023	0.048	0.003			
17	0.039	0.027	0.035	-----			
18	0.043	0.023	0.039	0.003			
19	0.052	0.029	0.041	-----			
20	0.035	0.030	0.050	0.003			
21	0.042	0.036	0.039	0.007			
22	0.043	0.029	0.031	-----			
23	0.040	0.031	0.034	-----			
24	0.048	0.031	-----	0.003			
25	0.048	0.032	0.033	0.005			
26	0.047	0.034	0.034	0.005			
27	0.046	0.035	0.035	0.005			
28	0.042	0.038	0.037	0.002			
29	0.049	0.037	0.044	0.003			
30	0.046	0.035	0.035	0.005			
31	0.048	0.047	0.032	0.003			
32	0.046	0.037	0.060	0.005			
33	0.052	0.043	0.032	0.003			
34	0.050	0.045	0.041	0.001			
35	0.050	0.044	0.043	-----			
36	0.048	0.044	0.036	0.007			
37	0.048	0.046	0.040	-----			
38	0.047	0.043	0.042	0.006			
39	0.060	0.043	0.038	0.003			
40	0.050	0.046	0.035	0.005			
			Test 2				
9	0.031	-----	-----	-----			
10	0.025	0.009	0.040	0.006			
11	0.032	0.007	0.048	0.010			
12	0.032	0.007	0.037	0.010			
13	0.035	0.010	0.048	0.009			
14	0.040	0.008	0.054	0.010			
15	0.041	0.017	0.053	0.015			
16	0.042	0.011	0.052	0.016			
17	0.045	0.019	0.059	0.010			
18	0.044	0.019	0.058	0.012			
19	0.051	0.020	0.052	0.015			
20	0.050	0.022	0.052	0.017			
21	-----	0.022	0.047	0.010			
22	0.044	0.019	0.059	0.015			
23	0.053	0.022	0.052	0.009			
24	0.049	0.029	0.051	0.012			
25	0.046	0.031	0.054	0.013			
26	0.050	0.027	-----	0.017			
27	0.053	0.032	0.047	0.011			
28	0.054	0.033	0.048	0.013			
29	0.055	0.038	0.048	0.011			
30	0.059	0.035	0.051	0.012			
31	0.056	0.036	0.052	0.017			
32	0.065	0.040	0.061	0.013			
33	0.064	0.038	0.048	0.017			
34	0.047	0.036	0.054	0.013			
35	0.055	0.041	0.051	0.017			
36	0.059	0.040	0.051	0.015			
37	0.058	0.042	0.051	0.013			
38	0.057	-----	0.056	0.013			
39	0.052	0.047	0.056	0.013			
40	0.057	0.045	0.059	0.016			
41	0.059	0.044	0.057	0.017			
42	0.056	0.046	0.058	0.015			
43	0.056	0.049	0.061	0.017			
44	0.058	0.043	0.065	0.018			
45	0.065	0.048	0.065	0.017			
46	0.061	0.047	0.061	0.016			
47	0.061	0.046	0.064	0.016			
48	0.060	0.051	0.047	0.017			
49	0.059	0.047	0.061	0.017			
50	0.059	0.043	0.062	0.017			
51	0.065	0.046	0.058	0.015			

Tidal Cycle	Low-water Slack Sta 100	High-water Slack Sta 100	Sta 20	Sta -10	Sta -35	Sta -60	Sta -85
			Test 3				
9	0.031	-----	-----	-----	-----		
10	0.021	0.000	0.047	0.017	-----		
11	0.025	0.002	0.053	0.016	-----		
12	0.028	0.003	0.054	0.022	-----		
13	0.031	0.001	0.052	0.021	-----		
14	0.031	0.005	0.064	0.020	-----		
15	0.031	0.010	0.065	0.027	-----		
16	0.035	0.004	0.064	0.031	-----		
17	0.040	0.007	0.062	0.027	-----		
18	0.042	0.011	0.070	0.031	-----		
19	0.043	0.007	0.069	0.029	-----		
20	0.045	0.007	0.069	0.030	-----		
21	0.042	0.010	0.076	0.038	-----		
22	0.048	0.005	0.082	0.044	0.007		
23	0.056	0.014	0.079	0.043	0.003		
24	0.053	0.015	0.078	0.040	0.004		
25	0.054	0.024	0.074	0.038	0.009		
26	0.056	0.021	0.081	0.045	0.005		
27	0.051	0.015	-----	0.041	0.007		
28	0.056	0.022	0.084	0.048	0.010		
29	0.059	0.017	0.093	0.049	0.011		
30	0.061	0.022	0.092	0.046	0.000		
31	0.057	0.024	0.097	0.047	0.015		
32	0.068	0.026	0.096	0.054	0.011		
33	0.066	0.024	0.098	0.050	0.014		
34	0.070	0.027	0.090	0.051	0.014		
35	0.072	0.031	0.099	0.052	0.014		
36	0.076	0.029	0.101	0.058	0.011		
37	-----	0.033	0.100	0.049	0.015		
38	0.081	0.036	0.104	0.061	0.013		
39	0.077	0.029	0.107	0.059	0.013		
40	0.081	0.033	0.097	0.054	0.014		
41	0.082	0.031	0.108	0.057	0.017		
42	0.085	0.035	0.103	0.052	0.013		
43	0.080	0.038	0.103	0.052	0.017		
44	0.091	0.040	0.102	0.061	0.011		
45	0.081	0.042	0.108	0.061	0.015		
46	0.088	0.040	0.124	0.055	0.014		
47	0.084	0.050	0.116	0.067	0.014		
48	0.082	0.047	0.110	0.058	0.012		
49	0.087	0.052	0.124	0.047	0.017		
50	0.090	0.046	0.119	0.057	0.014		
51	0.078	0.045	0.104	0.062	0.017		
52	0.096	0.052	0.112	0.061	-----		
53	0.103	0.050	0.117	0.061	0.017		
54	0.094	0.047	0.111	0.056	0.019		
55	0.098	0.045	0.118	0.064	0.025		
56	0.098	0.057	0.122	0.064	0.019		
57	-----	0.054	0.112	0.063	0.016		
58	0.102	0.056	0.129	0.064	0.019		
59	0.104	0.054	0.125	0.074	0.018		
60	0.102	0.055	0.128	0.068	0.025		
61	0.108	0.055	0.118	0.074	0.015		
62	0.104	0.068	0.130	0.062	0.023		
63	0.108	0.060	0.128	0.071	0.023		
64	0.110	0.064	0.130	0.072	0.024		
65	0.100	0.062	0.124	0.075	0.024		
66	0.107	0.061	0.129	0.070	0.025		
67	0.114	0.064	-----	-----	-----		
68	0.111	0.063	0.130	0.075	0.027		
69	0.115	0.063	0.134	0.077	0.025		
70	0.114	0.064	0.134	0.074	0.027		
71	0.101	0.076	0.128	0.077	0.021		
72	0.102	0.064	0.119	0.072	0.025		
73	0.103	0.066	0.144	0.073	0.023		
74	0.114	0.064	0.135	0.076	0.026		
75	0.117	0.072	0.133	0.075	0.028		
76	0.112	0.064	0.139	0.076	0.025		
77	0.114	0.078	0.140	0.084	0.025		
78	0.110	0.070	0.123	0.077	0.029		
79	0.121	0.073	0.136	0.082	0.023		
80	0.118	0.071	0.148	0.076	0.031		
81	0.112	0.075	0.140	0.072	0.030		
82	-----	0.068	0.139	-----	-----		
83	-----	-----	0.142	0.084	-----		
84	-----	-----	0.137	-----	0.029		
85	0.123	-----	0.133	-----	-----		

(Continued)

Table 2 (Continued)

Tidal Cycle	Low-water Slack Sta 100	High-water Slack Sta 100	Sta 20	Sta -10	Sta -35	Sta -60	Sta -85
		Test 3 (Continued)					
86	-----	0.079	0.144	-----	-----		
87	-----	-----	0.139	0.085	-----		
88	-----	-----	0.132	-----	0.035		
89	0.129	-----	0.136	-----	-----		
90	-----	0.076	0.139	-----	-----		
91	-----	-----	0.132	0.085	-----		
92	-----	-----	0.139	-----	0.028		
93	0.130	-----	0.144	-----	-----		
94	-----	0.087	0.137	-----	-----		
95	-----	-----	0.122	0.090	-----		
96	-----	-----	0.129	-----	0.029		
97	0.112	-----	0.141	-----	-----		
98	-----	0.085	0.142	-----	-----		
99	-----	-----	0.150	0.089	-----		
100	-----	-----	0.144	-----	0.033		
101	0.134	-----	0.134	-----	-----		
102	-----	0.084	0.143	-----	-----		
103	-----	-----	0.153	0.090	-----		
104	-----	-----	0.159	-----	0.032		
105	0.136	-----	0.145	-----	-----		
106	-----	0.092	0.157	-----	-----		
107	-----	-----	0.149	0.094	-----		
108	-----	-----	0.158	-----	0.032		
109	0.139	-----	0.157	-----	-----		
110	-----	0.099	0.152	-----	-----		
111	-----	-----	0.166	0.094	-----		
112	-----	-----	0.150	-----	0.033		
113	0.138	-----	0.148	-----	-----		
114	-----	-----	0.149	-----	-----		
115	-----	-----	0.147	0.095	-----		
116	-----	-----	0.155	-----	0.029		
117	0.139	-----	0.149	-----	-----		
118	-----	0.104	0.169	-----	-----		
119	-----	-----	-----	0.095	-----		
120	0.139	0.098	0.155	0.096	0.032		
			Test 4				
9	0.025	-----	-----	-----	-----	-----	
10	0.021	0.002	0.049	0.021	-----	-----	
11	0.025	0.008	0.056	0.030	-----	-----	
12	0.030	0.008	0.056	0.030	-----	-----	
13	0.030	0.003	0.063	0.038	-----	-----	
14	0.030	-----	0.065	0.032	-----	-----	
15	-----	-----	-----	0.043	-----	-----	
16	-----	-----	0.073	-----	0.010	-----	
17	0.041	-----	0.078	-----	-----	-----	
18	-----	0.010	0.082	-----	-----	-----	
19	-----	-----	0.077	0.049	-----	-----	
20	-----	-----	-----	-----	0.014	-----	
21	0.049	-----	0.089	-----	-----	-----	
22	-----	0.016	0.087	-----	-----	-----	
23	-----	-----	0.097	0.056	-----	-----	
24	-----	-----	0.095	-----	0.021	-----	
25	0.054	-----	0.089	-----	-----	-----	
26	-----	0.016	0.095	-----	-----	-----	
27	-----	-----	0.097	0.069	-----	-----	
28	-----	-----	0.104	-----	0.016	-----	
29	0.060	-----	0.103	-----	-----	-----	
30	-----	0.038	0.101	-----	-----	-----	
31	-----	-----	0.106	0.071	-----	-----	
32	-----	-----	0.104	-----	0.022	-----	
33	0.072	-----	-----	-----	-----	-----	
34	-----	0.030	0.104	-----	-----	-----	
35	-----	-----	0.115	0.071	-----	-----	
36	-----	-----	-----	-----	0.011	-----	
37	0.077	-----	0.110	-----	-----	-----	
38	-----	0.032	0.117	-----	-----	-----	
39	-----	-----	0.120	0.079	-----	-----	
40	-----	-----	0.117	-----	0.023	-----	
41	0.082	-----	0.120	-----	-----	-----	
42	-----	0.038	0.130	-----	-----	-----	
43	-----	-----	0.128	0.081	-----	-----	
44	-----	-----	0.129	-----	0.030	-----	
45	0.087	-----	0.129	-----	-----	-----	
46	-----	0.034	0.127	-----	-----	-----	
47	-----	-----	0.134	0.093	-----	-----	
48	-----	-----	0.133	-----	0.031	-----	
49	0.101	-----	0.121	-----	-----	-----	
50	-----	0.046	0.137	-----	-----	-----	
		Test 4 (Continued)					
51	-----	-----	0.139	0.096	-----	-----	
52	-----	-----	0.135	-----	0.022	-----	
53	-----	-----	0.141	-----	-----	-----	
54	-----	0.041	0.143	-----	-----	-----	
55	-----	-----	0.150	0.087	-----	-----	
56	-----	-----	0.146	-----	0.039	-----	
57	0.105	-----	0.143	-----	-----	-----	
58	-----	0.052	0.137	-----	-----	-----	
59	-----	-----	0.135	0.087	-----	-----	
60	-----	-----	0.147	-----	0.038	-----	
61	0.113	-----	0.141	-----	-----	-----	
62	-----	0.057	0.148	-----	-----	-----	
63	-----	-----	0.153	0.097	-----	-----	
64	-----	-----	-----	-----	0.038	-----	
65	-----	-----	0.146	-----	-----	0.010	
66	0.119	-----	0.156	-----	-----	-----	
67	-----	0.056	0.159	-----	-----	-----	
68	-----	-----	0.148	0.105	-----	-----	
69	-----	-----	0.155	-----	0.043	-----	
70	-----	-----	0.150	-----	-----	0.007	
71	0.117	-----	0.157	-----	-----	-----	
72	-----	0.069	0.161	-----	-----	-----	
73	-----	-----	0.163	0.106	-----	-----	
74	-----	-----	0.160	-----	0.049	-----	
75	-----	-----	0.165	-----	-----	0.014	
76	0.122	-----	0.152	-----	-----	-----	
77	-----	0.073	0.162	-----	-----	-----	
78	-----	-----	0.162	0.113	-----	-----	
79	-----	-----	0.160	-----	0.047	-----	
80	-----	-----	0.166	-----	-----	0.017	
81	0.133	-----	-----	-----	-----	-----	
82	-----	0.070	0.165	-----	-----	-----	
83	-----	-----	0.161	0.114	-----	-----	
84	-----	-----	0.168	-----	0.058	-----	
85	-----	-----	0.170	-----	-----	0.012	
86	0.136	-----	0.174	-----	-----	-----	
87	-----	0.082	0.178	-----	-----	-----	
88	-----	-----	0.174	0.122	-----	-----	
89	-----	-----	0.174	-----	0.058	-----	
90	-----	-----	0.172	-----	-----	0.017	
91	0.142	-----	0.171	-----	-----	-----	
92	-----	0.082	0.183	-----	-----	-----	
93	-----	-----	0.170	0.126	-----	-----	
94	-----	-----	0.179	-----	0.060	0.016	
95	0.145	-----	0.180	-----	-----	-----	
96	-----	0.084	0.194	-----	-----	-----	
97	-----	-----	0.184	0.137	-----	0.023	
98	-----	-----	0.172	-----	0.054	0.019	
99	-----	-----	0.184	-----	-----	0.024	
100	0.146	-----	0.178	-----	-----	0.023	
101	-----	0.089	0.180	-----	-----	-----	
102	-----	-----	0.181	0.135	-----	-----	
103	-----	-----	0.181	-----	-----	-----	
104	-----	-----	0.189	-----	-----	0.023	
105	0.159	-----	0.198	-----	-----	-----	
106	-----	0.093	0.183	-----	-----	-----	
107	-----	-----	0.192	0.137	-----	-----	
108	-----	-----	-----	-----	0.069	-----	
109	-----	-----	-----	-----	-----	0.020	
110	0.148	-----	0.178	-----	-----	-----	
111	-----	0.097	0.198	-----	-----	-----	
112	-----	-----	0.195	0.141	-----	-----	
113	-----	-----	0.201	-----	0.069	-----	
114	-----	-----	0.196	-----	-----	0.019	
115	0.170	-----	0.194	-----	-----	-----	
116	-----	0.099	0.202	-----	-----	-----	
117	-----	-----	0.198	0.133	-----	-----	
118	-----	-----	0.196	-----	0.070	-----	
119	-----	-----	-----	-----	-----	0.017	
120	0.161	0.104	0.183	0.145	0.062	0.023	
			Test 5				
9	0.048	-----	-----	-----	-----		
10	0.060	0.015	0.078	0.035	0.006		
11	-----	-----	0.080	0.019	0.006		
12	-----	0.021	-----	-----	-----		
13	-----	-----	0.072	0.029	-----		
14	0.068	-----	0.075	-----	0.006		
15	-----	0.032	0.076	-----	-----		

(Continued)

Table 2 (Continued)

Tidal Cycle	Low-water Slack Sta 100	High-water Slack Sta 100	Sta 20	Sta -10	Sta -35	Sta -60	Sta -85
			Test 5 (Continued)				
16	-----	-----	0.074	0.019	-----		
17	0.079	-----	0.075	-----	0.012		
18	-----	0.044	0.091	-----	-----		
19	-----	-----	0.078	0.025	-----		
20	0.082	-----	0.082	-----	0.004		
21	-----	0.048	0.085	-----	-----		
22	-----	-----	0.085	0.033	-----		
23	0.088	-----	0.136	-----	0.008		
24	-----	0.054	0.138	-----	-----		
25	-----	-----	0.118	0.036	-----		
26	0.102	-----	0.119	-----	0.013		
27	-----	0.068	0.123	-----	-----		
28	-----	-----	0.120	0.042	-----		
29	0.117	-----	0.116	-----	0.006		
30	-----	0.070	0.119	-----	-----		
31	-----	-----	0.114	0.037	-----		
32	0.109	-----	0.130	-----	0.008		
33	-----	0.082	0.136	-----	-----		
34	-----	-----	0.137	0.050	-----		
35	0.129	-----	0.126	-----	0.013		
36	-----	-----	0.134	-----	-----		
37	-----	-----	0.132	-----	-----		
38	0.140	-----	0.146	-----	0.010		
39	-----	0.092	0.137	-----	-----		
40	-----	-----	0.148	0.040	-----		
41	0.147	-----	0.145	-----	0.013		
42	-----	0.105	0.135	-----	-----		
43	-----	-----	0.131	0.045	-----		
44	0.136	-----	0.131	-----	0.008		
45	-----	0.113	0.146	-----	-----		
46	-----	-----	0.137	0.049	-----		
47	0.151	-----	0.149	-----	0.013		
48	-----	0.118	0.146	-----	-----		
49	-----	-----	0.154	0.044	-----		
50	-----	-----	-----	-----	-----		
51	-----	0.126	0.176	-----	-----		
52	-----	-----	0.148	0.052	-----		
53	0.160	-----	0.141	-----	0.015		
54	-----	0.136	0.143	-----	-----		
55	-----	-----	0.157	0.051	-----		
56	0.156	-----	0.148	-----	0.009		
57	-----	0.137	0.142	-----	-----		
58	-----	-----	0.139	0.046	-----		
59	0.158	-----	0.130	-----	0.013		
60	0.155	0.142	0.128	0.044	0.008		
			Test 6				
9	0.040	-----	-----	-----	-----	-----	
10	0.048	0.006	0.116	0.048	0.006	-----	
11	-----	-----	0.114	0.065	0.020	-----	
12	-----	0.015	0.115	-----	-----	-----	
13	-----	-----	0.140	0.076	-----	-----	
14	0.061	-----	0.141	-----	0.015	-----	
15	-----	0.024	0.132	-----	-----	-----	
16	-----	-----	0.161	0.078	-----	-----	
17	0.080	-----	0.158	-----	0.018	-----	
18	-----	0.015	0.151	-----	-----	-----	
19	-----	-----	0.147	0.082	-----	-----	
20	0.097	-----	0.148	-----	0.022	-----	
21	-----	0.029	0.148	-----	-----	-----	
22	-----	-----	0.153	0.095	-----	-----	
23	0.128	-----	0.153	-----	0.017	-----	
24	-----	0.041	0.170	-----	-----	-----	
25	-----	-----	0.160	-----	-----	-----	
26	0.129	-----	0.172	-----	0.013	-----	
27	-----	0.037	0.210	-----	-----	-----	
28	-----	-----	0.199	0.120	-----	-----	
29	0.140	-----	0.204	-----	0.035	-----	
30	-----	0.055	0.204	-----	-----	-----	
31	-----	-----	0.201	0.123	-----	-----	
32	0.154	-----	0.205	-----	0.035	-----	
33	-----	0.063	0.198	-----	-----	-----	
34	-----	-----	0.199	0.130	-----	-----	
35	0.171	-----	0.195	-----	0.039	-----	
36	-----	0.085	0.210	-----	-----	-----	
37	-----	-----	0.199	0.114	-----	-----	
38	0.176	-----	0.204	-----	0.036	-----	
39	-----	0.086	0.203	-----	-----	-----	
40	-----	-----	0.209	0.125	-----	-----	
41	0.167	-----	0.200	-----	0.041	-----	
			Test 6 (Continued)				
42	-----	0.089	0.206	-----	-----	-----	
43	-----	-----	0.215	0.131	-----	-----	
44	0.191	-----	0.256	-----	0.041	-----	
45	-----	0.092	0.260	-----	-----	-----	
46	-----	-----	0.255	0.140	-----	-----	
47	-----	-----	0.244	-----	0.041	-----	
48	0.198	-----	0.265	-----	-----	0.010	
49	-----	0.108	0.247	-----	-----	-----	
50	-----	-----	0.242	0.149	-----	-----	
51	-----	-----	0.240	-----	0.057	-----	
52	0.210	-----	0.238	-----	-----	0.015	
53	-----	0.106	0.230	-----	-----	-----	
54	-----	-----	0.230	0.142	-----	-----	
55	-----	-----	0.215	-----	0.051	-----	
56	0.214	-----	0.234	-----	-----	0.010	
57	-----	0.120	0.229	-----	-----	-----	
58	-----	-----	0.226	0.141	-----	-----	
59	-----	-----	0.224	-----	0.056	-----	
60	0.216	-----	0.229	-----	-----	0.008	
61	-----	0.136	0.222	-----	-----	-----	
62	-----	-----	0.241	0.137	-----	-----	
63	-----	-----	0.237	-----	0.054	-----	
64	0.220	-----	0.245	-----	-----	0.013	
65	-----	0.147	0.267	-----	-----	-----	
66	-----	-----	0.259	0.158	-----	-----	
67	-----	-----	0.256	-----	0.059	-----	
68	0.230	-----	0.253	-----	-----	0.013	
69	-----	0.150	0.253	-----	-----	-----	
70	-----	-----	0.248	0.159	-----	-----	
71	-----	-----	0.237	-----	0.058	-----	
72	0.232	-----	0.245	-----	-----	0.013	
73	-----	0.156	0.246	-----	-----	-----	
74	-----	-----	0.243	0.159	-----	-----	
75	-----	-----	0.244	-----	0.065	-----	
76	0.230	-----	0.247	-----	-----	0.017	
77	-----	0.162	0.239	-----	-----	-----	
78	-----	-----	0.247	0.149	-----	-----	
79	-----	-----	0.222	-----	0.056	-----	
80	0.235	-----	0.232	-----	-----	0.011	
81	-----	0.172	0.238	-----	-----	-----	
82	-----	-----	0.250	0.145	-----	-----	
83	-----	-----	0.260	-----	0.058	-----	
84	0.237	-----	0.313	-----	-----	0.016	
85	-----	0.171	0.303	-----	-----	-----	
86	-----	-----	0.299	0.177	-----	-----	
87	-----	-----	0.291	-----	0.053	-----	
88	-----	-----	0.299	-----	-----	0.019	
89	-----	-----	0.272	-----	-----	-----	
90	-----	-----	0.291	0.179	-----	-----	
91	-----	-----	0.285	-----	0.071	-----	
92	0.266	-----	0.284	-----	-----	0.021	
93	-----	0.204	0.290	-----	-----	-----	
94	-----	-----	0.279	0.182	-----	-----	
95	-----	-----	0.279	-----	0.066	-----	
96	0.275	-----	0.274	-----	-----	0.015	
97	-----	0.194	0.268	-----	-----	-----	
98	-----	-----	0.253	-----	-----	-----	
99	-----	-----	0.267	-----	0.080	-----	
100	0.266	-----	0.287	-----	-----	0.022	
101	-----	0.203	0.279	-----	-----	-----	
102	-----	-----	0.264	0.185	-----	-----	
103	-----	-----	0.296	-----	0.074	-----	
104	0.277	-----	0.304	-----	-----	0.016	
105	-----	0.208	0.322	-----	-----	-----	
106	-----	-----	0.318	0.192	-----	-----	
107	-----	-----	0.323	-----	0.082	-----	
108	0.277	-----	0.313	-----	-----	0.026	
109	-----	0.212	0.314	-----	-----	-----	
110	-----	-----	0.312	0.209	-----	-----	
111	-----	-----	0.308	-----	0.082	-----	
112	0.287	-----	0.305	-----	-----	0.017	
113	-----	0.223	0.286	-----	-----	-----	
114	-----	-----	0.310	0.203	-----	-----	
115	-----	-----	0.287	-----	0.091	-----	
116	-----	-----	0.285	-----	-----	0.029	
117	-----	0.226	0.296	-----	-----	-----	
118	-----	-----	0.289	0.198	-----	-----	
119	-----	-----	0.289	-----	0.086	0.030	
120	0.284	0.223	0.273	0.182	0.080	0.020	

(Continued)

Table 2 (Continued)

Tidal Cycle	Low-water Slack Sta 100	High-water Slack Sta 100	Sta 20	Sta -10	Sta -35	Sta -60	Sta -85
			Test 7				
9	0.026	-----	-----	-----	-----	-----	-----
10	0.014	0.003	0.049	0.027	0.005	-----	-----
11	-----	-----	0.047	0.031	-----	-----	-----
12	-----	0.005	-----	-----	-----	-----	-----
13	-----	-----	0.058	0.042	-----	-----	-----
14	-----	-----	0.065	-----	0.011	-----	-----
15	0.022	-----	0.069	-----	-----	-----	-----
16	-----	0.009	0.075	-----	-----	-----	-----
17	-----	-----	0.077	0.053	-----	-----	-----
18	-----	-----	0.079	-----	0.012	-----	-----
19	-----	0.013	0.083	-----	-----	-----	-----
20	-----	-----	0.076	0.058	-----	-----	-----
21	0.043	-----	0.083	-----	0.013	-----	-----
22	-----	0.014	0.087	-----	-----	-----	-----
23	-----	-----	0.089	0.057	-----	-----	-----
24	0.049	-----	0.096	-----	0.015	-----	-----
25	-----	0.012	0.094	-----	-----	-----	-----
26	-----	-----	0.095	0.070	-----	-----	-----
27	0.055	-----	0.096	-----	0.018	-----	-----
28	-----	0.029	0.100	-----	-----	-----	-----
29	-----	-----	0.101	0.075	-----	-----	-----
30	0.059	-----	0.103	-----	0.015	-----	-----
31	-----	0.018	0.108	-----	-----	-----	-----
32	-----	-----	0.109	0.076	-----	-----	-----
33	0.067	-----	0.106	-----	-----	-----	-----
34	-----	0.032	0.106	-----	-----	-----	-----
35	-----	-----	0.109	0.083	-----	-----	-----
36	0.069	-----	0.118	-----	0.026	-----	-----
37	-----	0.037	0.115	-----	-----	-----	-----
38	-----	-----	0.117	0.079	-----	-----	-----
39	0.079	-----	0.119	-----	0.024	-----	-----
40	-----	0.036	0.120	-----	-----	-----	-----
41	-----	-----	0.117	0.088	-----	-----	-----
42	0.080	-----	0.106	-----	0.021	-----	-----
43	-----	-----	0.111	-----	-----	-----	-----
44	-----	-----	0.110	0.086	-----	-----	-----
45	0.084	-----	0.121	-----	0.032	-----	-----
46	-----	0.041	0.132	-----	-----	-----	-----
47	-----	-----	0.132	0.097	-----	-----	-----
48	0.091	-----	0.133	-----	0.028	-----	-----
49	-----	0.045	0.123	-----	-----	-----	-----
50	-----	-----	0.133	0.092	-----	-----	-----
51	0.091	-----	0.138	-----	0.032	-----	-----
52	-----	0.044	0.139	-----	-----	-----	-----
53	-----	-----	0.137	0.103	-----	-----	-----
54	-----	-----	0.144	-----	0.038	-----	-----
55	0.100	-----	0.143	-----	-----	-----	-----
56	-----	0.049	0.141	-----	-----	-----	-----
57	-----	-----	0.141	0.103	-----	-----	-----
58	0.101	-----	0.128	-----	0.038	-----	-----
59	-----	0.051	0.124	-----	-----	-----	-----
60	-----	-----	0.155	0.109	-----	-----	-----
61	-----	-----	0.161	-----	0.038	-----	-----
62	0.111	-----	0.165	-----	-----	0.011	-----
63	-----	0.053	0.158	-----	-----	-----	-----
64	-----	-----	0.157	0.115	-----	-----	-----
65	-----	-----	0.157	-----	0.044	-----	-----
66	0.116	-----	0.159	-----	-----	0.011	-----
67	-----	0.071	0.157	-----	-----	-----	-----
68	-----	-----	0.156	0.113	-----	-----	-----
69	-----	-----	0.149	-----	0.042	-----	-----
70	0.120	-----	0.160	-----	-----	0.009	-----
71	-----	0.066	0.162	-----	-----	-----	-----
72	-----	-----	0.162	0.112	-----	-----	-----
73	-----	-----	0.162	-----	0.048	-----	-----
74	0.127	-----	0.167	-----	-----	0.008	-----
75	-----	0.071	0.169	-----	-----	-----	-----
76	-----	-----	0.171	0.133	-----	-----	-----
77	-----	-----	0.169	-----	-----	-----	-----
78	0.133	-----	0.183	-----	-----	0.013	-----
79	-----	0.066	0.177	-----	-----	-----	-----
80	-----	-----	0.176	0.134	-----	-----	-----
81	-----	-----	0.185	-----	0.059	-----	-----
82	0.135	-----	0.175	-----	-----	0.026	-----
83	-----	0.074	0.171	-----	-----	-----	-----
84	-----	-----	0.193	0.139	-----	-----	-----
85	-----	-----	0.185	-----	0.055	-----	-----
86	0.148	-----	0.179	-----	-----	0.019	-----
87	-----	0.079	0.181	-----	-----	-----	-----
88	-----	-----	0.176	0.131	-----	-----	-----
89	-----	-----	0.178	-----	0.056	-----	-----
			Test 7 (Continued)				
90	0.146	-----	0.187	-----	-----	0.014	-----
91	-----	0.092	0.177	-----	-----	-----	-----
92	-----	-----	0.187	0.144	-----	-----	-----
93	-----	-----	0.185	-----	0.059	-----	-----
94	0.157	-----	0.177	-----	-----	0.016	-----
95	-----	0.086	0.197	-----	-----	-----	-----
96	-----	-----	0.182	0.143	-----	-----	-----
97	-----	-----	0.191	-----	0.067	-----	-----
98	0.156	-----	0.191	-----	-----	0.015	-----
99	-----	0.092	0.195	-----	-----	-----	-----
100	-----	-----	0.191	0.157	-----	-----	-----
101	-----	-----	0.187	-----	0.066	-----	-----
102	0.159	-----	0.195	-----	-----	0.019	-----
103	-----	0.091	0.201	-----	-----	-----	-----
104	-----	-----	0.195	0.149	-----	-----	-----
105	-----	-----	0.189	-----	0.069	-----	-----
106	0.160	-----	0.197	-----	-----	0.016	-----
107	-----	-----	0.193	-----	-----	-----	-----
108	-----	-----	0.189	0.153	-----	-----	-----
109	-----	-----	0.198	-----	0.063	-----	-----
110	0.166	-----	0.201	-----	-----	0.021	-----
111	-----	0.094	0.200	-----	-----	-----	-----
112	-----	-----	0.206	0.141	-----	-----	-----
113	-----	-----	0.201	-----	0.069	-----	-----
114	0.171	-----	0.197	-----	-----	0.021	-----
115	-----	0.120	0.206	-----	-----	-----	-----
116	-----	-----	0.203	0.158	-----	-----	-----
117	-----	-----	0.188	-----	0.067	-----	-----
118	0.176	-----	0.200	-----	-----	0.019	-----
119	-----	0.115	0.207	-----	-----	-----	-----
120	-----	-----	0.203	0.158	-----	-----	-----
121	-----	-----	0.222	-----	0.063	-----	-----
122	0.169	-----	0.214	-----	-----	0.021	-----
123	-----	0.127	0.207	-----	-----	-----	-----
124	-----	-----	0.203	0.161	-----	-----	-----
125	-----	-----	0.213	-----	0.070	-----	-----
126	0.171	-----	0.198	-----	-----	0.013	-----
127	-----	0.116	0.209	-----	-----	-----	-----
128	-----	-----	0.210	0.164	-----	-----	-----
129	-----	-----	0.207	-----	0.073	-----	-----
130	0.171	-----	0.213	-----	-----	0.022	-----
131	-----	0.121	0.208	-----	-----	-----	-----
132	-----	-----	0.187	0.165	-----	-----	-----
133	-----	-----	0.210	-----	0.071	-----	-----
134	0.185	-----	0.206	-----	-----	0.021	-----
135	-----	0.129	0.222	-----	-----	-----	-----
136	-----	-----	0.220	0.162	-----	-----	-----
137	-----	-----	0.216	-----	0.076	-----	-----
138	0.185	-----	0.223	-----	-----	0.024	-----
139	-----	0.129	0.221	-----	-----	-----	-----
140	-----	-----	0.212	0.165	-----	-----	-----
141	-----	-----	0.215	-----	0.078	-----	-----
142	0.190	-----	0.218	-----	-----	0.021	-----
143	-----	0.132	0.224	-----	-----	-----	-----
144	-----	-----	0.216	0.162	-----	-----	-----
145	-----	-----	0.214	-----	0.080	-----	-----
146	-----	-----	0.222	-----	-----	0.026	-----
147	-----	0.129	0.216	-----	-----	0.026	-----
148	-----	-----	0.225	0.179	-----	-----	-----
149	-----	-----	0.220	-----	0.078	-----	-----
150	0.191	-----	0.210	-----	-----	0.024	-----
151	-----	0.143	0.222	-----	-----	-----	-----
152	-----	-----	0.205	0.176	-----	-----	-----
153	-----	-----	0.221	-----	0.086	-----	-----
154	0.195	-----	0.222	-----	-----	0.026	-----
155	-----	-----	0.213	-----	-----	-----	-----
156	-----	-----	0.218	0.181	-----	-----	-----
157	-----	-----	0.218	-----	0.077	-----	-----
158	0.199	-----	0.219	-----	-----	0.027	-----
159	-----	0.155	0.232	-----	-----	-----	-----
160	-----	-----	0.227	0.167	-----	-----	-----
161	-----	-----	0.228	-----	0.086	-----	-----
162	0.199	-----	0.236	-----	-----	0.028	-----
163	-----	0.156	0.224	-----	-----	-----	-----
164	-----	-----	0.239	0.173	-----	-----	-----
165	-----	-----	0.239	-----	0.082	-----	-----
166	0.207	-----	0.227	-----	-----	0.037	-----
167	-----	0.149	0.222	-----	-----	-----	-----
168	-----	-----	0.230	0.181	-----	-----	-----
169	-----	-----	0.231	-----	0.095	-----	-----
170	0.198	-----	0.230	-----	-----	0.030	-----

(Continued)

Table 2 (Continued)

Tidal Cycle	Low-water Slack Sta 100	High-water Slack Sta 100	Sta 20	Sta -10	Sta -35	Sta -60	Sta -85
		Test 7 (Continued)					
171	-----	0.144	0.226	-----	-----	-----	-----
172	-----	-----	0.229	0.177	-----	-----	-----
173	-----	-----	0.220	-----	0.081	-----	-----
174	0.209	-----	0.235	-----	-----	0.030	-----
175	-----	0.149	0.242	-----	-----	-----	-----
176	-----	-----	0.231	0.183	-----	-----	-----
177	-----	-----	0.236	-----	0.094	-----	-----
178	0.212	-----	0.231	-----	-----	0.024	-----
179	-----	0.150	0.228	-----	-----	-----	-----
180	-----	-----	0.234	0.186	-----	-----	-----
181	-----	-----	0.228	-----	0.083	-----	-----
182	0.216	-----	0.226	-----	-----	0.028	-----
183	-----	0.157	0.228	-----	-----	-----	-----
184	-----	-----	0.217	0.177	-----	-----	-----
185	-----	-----	0.218	-----	0.090	-----	-----
186	0.203	-----	0.228	-----	-----	0.024	-----
187	-----	0.156	0.236	-----	-----	-----	-----
188	-----	-----	0.242	0.179	-----	-----	-----
189	-----	-----	0.239	-----	0.079	-----	-----
190	-----	-----	0.240	-----	-----	0.029	-----
191	0.212	-----	0.250	-----	-----	0.034	-----
192	-----	0.170	0.261	-----	-----	-----	-----
193	-----	-----	0.255	0.198	-----	-----	-----
194	-----	-----	0.246	-----	0.076	-----	-----
195	0.214	-----	0.234	-----	-----	0.028	-----
196	-----	0.166	0.231	-----	-----	-----	-----
197	-----	-----	0.227	0.191	-----	-----	-----
198	-----	-----	0.231	-----	0.086	-----	-----
199	0.218	-----	0.243	-----	-----	0.033	-----
200	-----	0.160	-----	-----	-----	-----	-----
201	-----	-----	0.239	0.179	-----	-----	-----
202	-----	-----	0.247	-----	0.087	-----	-----
203	0.222	-----	0.238	-----	-----	0.028	-----
204	-----	-----	0.235	-----	-----	-----	-----
205	-----	0.176	0.222	0.181	-----	-----	-----
206	-----	-----	0.232	-----	0.086	-----	-----
207	0.209	-----	0.240	-----	-----	0.036	-----
208	-----	0.169	0.237	-----	-----	-----	-----
209	-----	-----	0.238	0.183	-----	-----	-----
210	-----	-----	0.244	-----	0.086	-----	-----
211	0.225	-----	-----	-----	-----	0.021	-----
212	-----	0.176	0.242	-----	-----	-----	-----
213	-----	-----	0.243	0.187	-----	-----	0.003
214	-----	-----	0.248	-----	0.084	-----	-----
215	0.218	-----	0.230	-----	-----	0.022	0.005
216	-----	0.172	0.251	-----	-----	-----	-----
217	-----	-----	0.245	-----	-----	-----	0.007
218	-----	-----	0.239	-----	0.082	-----	-----
219	0.222	-----	0.241	-----	-----	0.034	0.016
220	-----	0.168	0.246	-----	-----	-----	-----
221	-----	-----	0.248	0.184	-----	-----	0.004
222	-----	-----	0.241	-----	0.088	-----	-----
223	0.219	-----	0.249	-----	-----	0.025	0.015
224	-----	0.171	0.239	-----	-----	-----	-----
225	-----	-----	0.251	0.194	-----	-----	0.012
226	-----	-----	0.234	-----	0.095	-----	-----
227	0.220	-----	0.245	-----	-----	0.028	0.011
228	-----	0.174	0.241	-----	-----	-----	-----
229	-----	-----	0.241	0.189	-----	-----	0.009
230	-----	-----	0.253	-----	0.096	-----	-----
231	0.218	-----	0.244	-----	-----	0.025	0.009
232	-----	0.179	0.237	-----	-----	-----	-----
233	-----	-----	0.246	0.196	-----	-----	0.014
234	-----	-----	0.249	-----	0.094	-----	-----
235	0.221	-----	0.243	-----	-----	0.031	0.017
236	-----	0.183	0.257	-----	-----	-----	-----
237	-----	-----	0.243	0.192	-----	-----	-----
238	-----	-----	-----	-----	-----	-----	-----
239	-----	-----	-----	-----	-----	-----	-----
240	0.230	0.171	0.253	0.193	0.094	0.035	0.014
			Test 8				
9	0.037	-----	-----	-----	-----	-----	
10	0.046	0.008	0.056	0.021	0.005	-----	
11	-----	-----	0.050	0.016	0.007	-----	
12	-----	0.017	0.054	-----	-----	-----	
13	-----	-----	0.056	0.012	-----	-----	
14	0.056	-----	0.061	-----	0.009	-----	
15	-----	0.017	0.071	-----	-----	-----	
16	-----	-----	0.069	0.022	-----	-----	
		Test 8 (Continued)					
17	0.050	-----	0.069	-----	0.009	-----	
18	-----	0.019	0.064	-----	-----	-----	
19	-----	-----	0.074	0.031	-----	-----	
20	0.063	-----	0.075	-----	0.005	-----	
21	-----	0.021	0.079	-----	-----	-----	
22	-----	-----	0.081	0.034	-----	-----	
23	0.061	-----	0.074	-----	0.011	-----	
24	-----	0.027	0.090	-----	-----	-----	
25	-----	-----	0.086	0.038	-----	-----	
26	0.063	-----	0.086	-----	0.020	-----	
27	-----	0.030	0.089	-----	-----	-----	
28	-----	-----	0.085	0.038	-----	-----	
29	0.078	-----	0.090	-----	0.012	-----	
30	-----	0.034	0.090	-----	-----	-----	
31	-----	-----	0.095	0.043	-----	-----	
32	0.085	-----	0.092	-----	0.014	-----	
33	-----	0.041	0.100	-----	-----	-----	
34	-----	-----	0.100	0.049	-----	-----	
35	0.085	-----	0.108	-----	0.015	-----	
36	-----	0.048	0.105	-----	-----	-----	
37	-----	-----	0.102	0.048	-----	-----	
38	0.094	-----	0.120	-----	0.015	-----	
39	-----	0.054	0.115	-----	-----	-----	
40	-----	-----	0.106	0.047	-----	-----	
41	0.102	-----	0.117	-----	0.018	-----	
42	-----	0.055	0.110	-----	-----	-----	
43	-----	-----	0.117	0.054	-----	-----	
44	0.104	-----	0.120	-----	0.019	-----	
45	-----	0.062	0.102	-----	-----	-----	
46	-----	-----	0.111	0.058	-----	-----	
47	0.109	-----	0.117	-----	0.018	-----	
48	-----	0.070	0.111	-----	-----	-----	
49	-----	-----	0.115	0.057	-----	-----	
50	0.114	-----	0.121	-----	0.019	-----	
51	-----	0.078	0.114	-----	-----	-----	
52	-----	-----	0.119	0.061	-----	-----	
53	0.126	-----	0.117	-----	0.020	-----	
54	-----	0.072	0.128	-----	-----	-----	
55	-----	-----	0.120	0.069	-----	-----	
56	0.134	-----	0.123	-----	-----	-----	
57	-----	0.087	0.123	-----	-----	-----	
58	-----	-----	0.122	0.064	-----	-----	
59	0.124	-----	0.126	-----	0.026	-----	
60	-----	0.078	0.128	-----	-----	-----	
61	-----	-----	0.125	0.062	-----	-----	
62	0.125	-----	0.122	-----	0.025	-----	
63	-----	0.082	0.134	-----	-----	-----	
64	-----	-----	0.131	0.066	-----	-----	
65	0.130	-----	0.124	-----	0.022	-----	
66	-----	0.084	0.131	-----	-----	-----	
67	-----	-----	0.131	0.066	-----	-----	
68	0.133	-----	0.133	-----	0.025	-----	
69	-----	0.084	0.138	-----	-----	-----	
70	0.134	-----	0.131	-----	-----	-----	
71	-----	0.088	0.150	-----	-----	-----	
72	-----	-----	0.132	0.068	-----	-----	
73	0.136	-----	0.134	-----	0.028	-----	
74	-----	0.104	0.135	-----	-----	-----	
75	-----	-----	0.133	0.067	-----	-----	
76	0.136	-----	0.129	-----	0.031	-----	
77	-----	0.095	0.143	-----	-----	-----	
78	-----	-----	0.140	0.078	-----	-----	
79	0.143	-----	0.141	-----	0.031	-----	
80	-----	0.103	0.141	-----	-----	-----	
81	-----	-----	0.140	0.077	-----	-----	
82	0.143	-----	0.139	-----	0.029	-----	
83	-----	0.097	0.135	-----	-----	-----	
84	-----	-----	0.129	0.069	-----	-----	
85	0.143	-----	0.143	-----	0.027	-----	
86	-----	0.101	0.138	-----	-----	-----	
87	-----	-----	0.147	0.080	-----	-----	
88	0.137	-----	0.150	-----	0.029	-----	
89	-----	0.115	0.142	-----	-----	-----	
90	-----	-----	0.147	0.082	-----	-----	
91	0.146	-----	0.138	-----	0.034	-----	
92	-----	0.107	0.144	-----	-----	-----	
93	-----	-----	0.160	0.082	-----	-----	
94	-----	-----	0.141	-----	0.024	-----	
95	0.151	-----	0.149	-----	-----	0.010	
96	-----	0.118	0.148	-----	-----	-----	

(Continued)

Table 2 (Continued)

Tidal Cycle	Low-water Slack	High-water Slack					
	Sta 100	Sta 100	Sta 20	Sta -10	Sta -35	Sta -60	Sta -85
		Test 8 (Continued)					
97	-----	-----	0.146	0.079	-----	-----	
98	-----	-----	0.149	-----	0.028	-----	
99	0.150	-----	0.147	-----	-----	0.011	
100	-----	0.110	0.151	-----	-----	-----	
101	-----	-----	0.148	0.082	-----	-----	
102	-----	-----	0.146	-----	0.032	-----	
103	0.150	-----	0.157	-----	-----	0.010	
104	-----	0.116	0.152	-----	-----	-----	
105	-----	-----	0.145	0.081	-----	-----	
106	-----	-----	0.148	-----	0.032	-----	
107	0.153	-----	0.147	-----	-----	0.012	
108	-----	0.118	0.150	-----	-----	-----	
109	-----	-----	0.143	0.076	-----	-----	
110	-----	-----	0.142	-----	0.031	-----	
111	0.154	-----	0.145	-----	-----	0.008	
112	-----	0.118	0.149	-----	-----	-----	
113	-----	-----	0.153	0.080	-----	-----	
114	-----	-----	0.150	-----	0.031	-----	
115	0.155	-----	0.143	-----	-----	0.005	
116	-----	0.126	0.154	-----	-----	-----	
117	-----	-----	0.151	0.085	-----	-----	
118	-----	-----	0.151	-----	0.033	-----	
119	0.163	-----	0.155	-----	-----	0.006	
120	0.163	0.118	0.147	0.085	0.031	0.010	
			Test 9				
9	0.024	-----	-----	-----	-----	-----	
10	-----	0.011	0.053	0.020	-----	-----	
11	0.030	-----	0.053	-----	0.009	-----	
12	-----	0.011	0.051	-----	-----	-----	
13	-----	-----	0.055	0.036	-----	-----	
14	0.046	-----	0.065	-----	0.008	-----	
15	-----	0.008	0.065	-----	-----	-----	
16	-----	-----	0.063	0.029	-----	-----	
17	0.041	-----	0.060	-----	0.010	-----	
18	-----	0.014	0.061	-----	-----	-----	
19	-----	-----	0.053	0.032	-----	-----	
20	0.043	-----	0.051	-----	0.016	-----	
21	-----	0.017	0.058	-----	-----	-----	
22	-----	-----	0.075	0.030	-----	-----	
23	0.044	-----	0.072	-----	0.013	-----	
24	-----	0.016	0.080	-----	-----	-----	
25	-----	-----	0.081	0.033	-----	-----	
26	0.050	-----	0.073	-----	0.015	-----	
27	-----	0.025	0.069	-----	-----	-----	
28	-----	-----	0.066	0.048	-----	-----	
29	0.045	-----	0.078	-----	0.009	-----	
30	-----	0.031	0.065	-----	-----	-----	
31	-----	-----	0.066	0.040	-----	-----	
32	0.059	-----	0.085	-----	0.008	-----	
33	-----	0.026	0.073	-----	-----	-----	
34	-----	-----	0.078	0.039	-----	-----	
35	0.057	-----	0.087	-----	0.013	-----	
36	-----	0.031	0.080	-----	-----	-----	
37	-----	-----	0.085	0.053	-----	-----	
38	0.070	-----	0.092	-----	0.015	-----	
39	-----	0.031	0.097	-----	-----	-----	
40	-----	-----	0.091	0.048	-----	-----	
41	0.068	-----	0.090	-----	0.015	-----	
42	-----	0.038	0.087	-----	-----	-----	
43	-----	-----	0.090	0.045	-----	-----	
44	0.069	-----	0.089	-----	0.015	-----	
45	-----	0.034	0.090	-----	-----	-----	
46	-----	-----	0.091	0.048	-----	-----	
47	0.078	-----	0.090	-----	0.013	-----	
48	-----	0.046	0.097	-----	-----	-----	
49	-----	-----	0.087	0.055	-----	-----	
50	0.077	-----	0.095	-----	0.020	-----	
51	-----	0.042	0.093	-----	-----	-----	

Tidal Cycle	Low-water Slack	High-water Slack					
	Sta 100	Sta 100	Sta 20	Sta -10	Sta -35	Sta -60	Sta -85
		Test 9 (Continued)					
52	-----	-----	0.094	0.057	-----	-----	
53	-----	-----	0.100	-----	0.025	-----	
54	0.083	-----	0.098	-----	-----	0.007	
55	-----	0.050	0.106	-----	-----	-----	
56	-----	-----	0.102	0.058	-----	-----	
57	-----	-----	0.098	-----	0.021	-----	
58	0.088	-----	0.100	-----	-----	0.009	
59	-----	0.052	0.097	-----	-----	-----	
60	-----	-----	0.095	0.063	-----	-----	
61	-----	-----	0.097	-----	0.024	-----	
62	0.087	-----	0.105	-----	-----	0.005	
63	-----	0.055	0.099	-----	-----	-----	
64	-----	-----	0.104	0.065	-----	-----	
65	-----	-----	0.106	-----	0.024	-----	
66	0.089	-----	0.114	-----	-----	0.010	
67	-----	0.066	0.116	-----	-----	-----	
68	-----	-----	0.135	0.075	-----	-----	
69	-----	-----	0.110	-----	0.022	-----	
70	0.090	-----	0.121	-----	-----	0.007	
71	-----	0.058	0.146	-----	-----	-----	
72	-----	-----	0.128	0.081	-----	-----	
73	-----	-----	0.122	-----	0.023	-----	
74	0.105	-----	0.134	-----	-----	0.007	
75	-----	-----	0.134	-----	-----	-----	
76	-----	-----	-----	0.080	-----	-----	
77	-----	-----	0.130	-----	0.026	-----	
78	0.112	-----	0.137	-----	-----	0.010	
79	-----	0.074	0.136	-----	-----	-----	
80	-----	-----	0.136	0.085	-----	-----	
81	-----	-----	0.142	-----	0.042	-----	
82	0.119	-----	0.119	-----	-----	0.009	
83	-----	0.076	0.125	-----	-----	-----	
84	-----	-----	0.130	0.083	-----	-----	
85	-----	-----	0.122	-----	0.032	-----	
86	0.117	-----	0.124	-----	-----	0.008	
87	-----	0.083	0.124	-----	-----	-----	
88	-----	-----	0.123	0.076	-----	-----	
89	-----	-----	0.130	-----	0.029	-----	
90	0.112	-----	0.122	-----	-----	0.010	
91	-----	0.079	0.132	-----	-----	-----	
92	-----	-----	0.126	0.071	-----	-----	
93	-----	-----	0.135	-----	0.029	-----	
94	0.116	-----	0.137	-----	-----	0.009	
95	-----	0.081	0.132	-----	-----	-----	
96	-----	-----	0.144	0.090	-----	-----	
97	-----	-----	0.149	-----	0.032	-----	
98	0.127	-----	0.152	-----	-----	0.017	
99	-----	0.086	0.135	-----	-----	-----	
100	-----	-----	0.137	0.086	-----	-----	
101	-----	-----	0.133	-----	0.042	-----	
102	0.133	-----	0.142	-----	-----	0.009	
103	-----	0.090	0.147	-----	-----	-----	
104	-----	-----	0.152	0.086	-----	-----	
105	-----	-----	0.142	-----	0.033	-----	
106	0.137	-----	0.146	-----	-----	0.014	
107	-----	0.099	0.150	-----	-----	-----	
108	-----	-----	0.144	0.094	-----	-----	
109	-----	-----	0.156	-----	0.035	-----	
110	0.137	-----	0.153	-----	-----	-----	
111	-----	0.105	0.150	-----	-----	-----	
112	-----	-----	0.154	0.101	-----	-----	
113	-----	-----	0.148	-----	0.038	-----	
114	0.138	-----	0.155	-----	-----	0.020	
115	-----	0.099	0.154	-----	-----	-----	
116	-----	-----	0.158	0.094	-----	-----	
117	-----	-----	0.152	-----	0.048	-----	
118	0.148	-----	0.164	-----	-----	0.014	
119	-----	0.112	0.157	-----	-----	-----	
120	0.150	0.104	0.161	0.100	0.042	0.014	

Note: Tidal cycle zero is the cycle in which discharge of plant effluent was begun.
Observations were made at times of local low-water slack or local high-water slack.
Stations are 1000-ft channel stations from Allegheny Ave., Philadelphia, as shown on plate 1.

Table 3

Results of Final Midchannel Observations

Dye Concentrations in Per Cent of Plant Effluent Concentration

1000-ft Sta*	Test 1 Preliminary		Test 1		Test 2		Test 3		Test 4		Test 5		Test 6		Test 7		Test 8		Test 9		Test 7 Cycle 120**	
	HW	LW	HW	LW	HW	LW	HW	LW	HW	LW	HW	LW	HW	LW	HW	LW	HW	LW	HW	LW	HW	LW
180	-----	0.035	0.019	0.035	0.015	0.031	0.022	0.051	0.023	0.054	0.050	0.100	0.066	0.143	0.055	0.115	0.036	0.082	0.027	0.066	0.019	0.056
140	-----	0.044	0.035	0.043	0.034	0.052	0.056	0.091	0.051	0.119	0.097	0.158	0.141	0.238	0.115	0.189	0.075	0.132	0.063	0.108	0.053	0.125
120	0.041	0.048	0.036	0.050	0.048	0.060	0.077	0.128	0.069	0.148	0.118	0.148	0.184	0.277	0.146	0.211	0.100	0.146	0.088	0.122	0.084	0.149
100	0.045	0.048	0.046	0.050	0.052	0.057	0.098	0.139	0.104	0.161	0.143	0.155	0.223	0.284	0.171	0.230	0.118	0.163	0.104	0.150	-----	0.169
80	0.047	0.037	0.044	0.060	0.058	0.074	0.118	0.165	0.134	0.201	0.151	0.154	0.256	0.306	0.203	0.244	0.142	0.181	0.130	0.161	-----	-----
70	-----	0.035	0.031	0.044	0.064	0.068	0.129	0.163	0.153	0.187	0.145	0.136	0.272	0.285	0.212	0.251	0.155	0.167	0.143	0.162	-----	-----
60	0.046	0.056	0.050	0.038	0.064	0.064	0.141	0.169	0.170	0.194	0.146	0.122	0.282	0.273	-----	0.245	0.157	0.158	0.148	0.155	0.171	0.224
50	-----	0.055	0.046	0.031	0.068	0.054	0.147	0.139	0.159	0.204	0.145	0.095	0.287	0.264	0.226	0.245	0.162	0.147	0.149	0.143	-----	-----
40	0.040	0.039	0.049	0.012	0.079	0.030	0.158	0.122	0.183	0.170	0.143	0.076	0.295	0.222	0.235	0.220	0.169	0.092	0.166	0.120	-----	-----
35	0.040	-----	0.042	0.012	0.070	0.025	0.167	0.097	0.194	0.151	0.139	0.056	0.286	0.208	0.247	0.212	0.167	0.092	0.165	0.104	-----	-----
30	0.045	0.011	0.043	0.005	0.070	0.019	0.162	0.090	0.203	0.146	0.123	0.049	0.284	0.177	0.234	0.179	0.165	0.081	0.111	0.103	0.187	0.146
25	-----	-----	-----	0.001	0.072	0.012	0.158	0.087	0.194	0.131	0.119	0.040	0.273	0.166	0.240	0.173	0.161	0.075	0.158	0.098	-----	-----
20	0.043	0.005	0.035	0.005	0.065	0.012	0.155	0.065	0.183	0.122	0.123	0.021	0.273	0.152	0.253	0.158	0.147	0.063	0.161	0.069	0.203	-----
15	-----	-----	0.027	0.005	0.070	0.005	0.152	0.057	0.188	0.100	0.119	0.021	0.284	0.134	0.245	0.129	0.157	0.052	0.157	0.065	-----	-----
10	0.031	-----	0.028	0.003	0.054	0.011	0.150	0.050	-----	0.091	0.104	0.020	0.258	0.122	0.248	0.117	0.139	0.047	0.152	0.061	-----	-----
5	-----	-----	0.014	-----	0.052	0.002	0.143	0.039	0.190	0.068	0.084	0.015	0.242	0.090	0.239	0.105	0.124	0.034	0.137	0.048	-----	-----
0	0.022	-----	0.013	0.003	0.040	0.005	0.134	0.025	0.181	0.058	0.081	0.007	0.245	0.059	0.235	0.079	0.099	0.022	0.130	0.025	0.206	0.061
-5	-----	-----	0.010	-----	0.027	0.001	0.102	0.019	0.169	0.045	0.055	0.006	0.211	0.049	0.220	0.066	0.102	0.018	0.118	0.024	-----	-----
-10	0.006	-----	0.005	-----	-----	0.002	0.096	0.017	0.145	0.043	0.044	0.013	0.182	0.040	0.193	0.056	0.085	0.014	0.100	0.018	0.158	-----
-15	-----	-----	0.004	-----	0.010	0.001	0.088	0.013	0.138	0.030	0.033	0.006	0.162	0.040	0.183	0.041	0.076	0.012	0.087	0.015	-----	-----
-20	0.003	-----	0.007	-----	0.007	0.003	0.070	0.009	0.115	0.023	0.034	0.006	0.139	0.034	0.159	0.033	0.066	0.009	0.080	0.014	0.127	0.021
-25	-----	-----	0.003	-----	0.009	-----	0.063	0.013	0.095	0.023	0.018	-----	0.125	0.023	0.135	0.033	0.058	0.010	0.073	0.011	-----	-----
-30	-----	-----	0.003	-----	0.006	-----	0.049	0.009	0.082	0.019	0.013	-----	0.099	0.012	0.120	0.021	0.043	0.006	0.067	0.006	-----	-----
-35	-----	-----	-----	-----	-----	-----	0.032	0.005	0.062	0.021	0.008	-----	0.080	-----	0.094	0.022	0.031	0.003	0.042	0.007	0.063	-----
-40	-----	-----	-----	-----	-----	-----	0.027	0.011	0.056	0.015	0.008	-----	0.069	0.010	0.071	0.014	0.026	0.003	0.028	0.009	0.057	0.009
-45	-----	-----	-----	-----	-----	-----	0.024	0.003	0.045	0.011	0.004	-----	0.049	-----	0.062	0.013	0.020	0.006	0.020	0.008	-----	-----
-50	-----	-----	-----	-----	-----	-----	0.018	0.007	0.038	0.007	0.010	-----	0.041	-----	0.050	0.007	0.015	0.003	0.020	0.008	-----	-----
-55	-----	-----	-----	-----	-----	-----	0.010	0.003	0.029	0.009	0.005	-----	0.025	-----	0.041	0.011	0.012	0.003	0.013	0.010	-----	-----
-60	-----	-----	-----	-----	-----	-----	0.010	-----	0.023	0.007	0.003	-----	0.020	-----	0.035	0.007	0.010	-----	0.014	-----	0.021	0.003
-65	-----	-----	-----	-----	-----	-----	0.008	-----	0.014	0.008	-----	-----	0.017	-----	0.023	0.008	0.007	-----	0.005	-----	-----	-----
-70	-----	-----	-----	-----	-----	-----	0.009	-----	0.016	-----	-----	-----	0.013	-----	0.018	-----	0.005	-----	0.008	-----	-----	-----
-75	-----	-----	-----	-----	-----	-----	0.007	-----	0.017	-----	-----	-----	0.013	-----	0.011	0.004	0.004	-----	0.005	-----	-----	-----
-80	-----	-----	-----	-----	-----	-----	-----	-----	0.014	-----	-----	-----	0.005	-----	0.008	-----	-----	-----	-----	-----	-----	-----
-85	-----	-----	-----	-----	-----	-----	-----	-----	0.007	-----	-----	-----	0.006	-----	0.014	-----	-----	-----	-----	-----	-----	-----
-90	-----	-----	-----	-----	-----	-----	-----	-----	0.009	-----	-----	-----	0.010	-----	0.009	-----	-----	-----	-----	-----	-----	-----
-95	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.003	-----	0.007	-----	-----	-----	-----	-----	-----	-----
-100	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.001	-----	0.008	-----	-----	-----	-----	-----	-----	-----
-105	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.005	-----	-----	-----	-----	-----	-----	-----
-110	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.010	-----	-----	-----	-----	-----	-----	-----
-115	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.009	-----	-----	-----	-----	-----	-----	-----
-120	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.005	-----	-----	-----	-----	-----	-----	-----

* Stations are channel stations and refer to Allegheny Ave., Philadelphia, located on plate 1. Observations were made at times of local high- or low-water slack (HW or LW).

** Test 7, cycle 120, observations included for comparison with results of test 4.

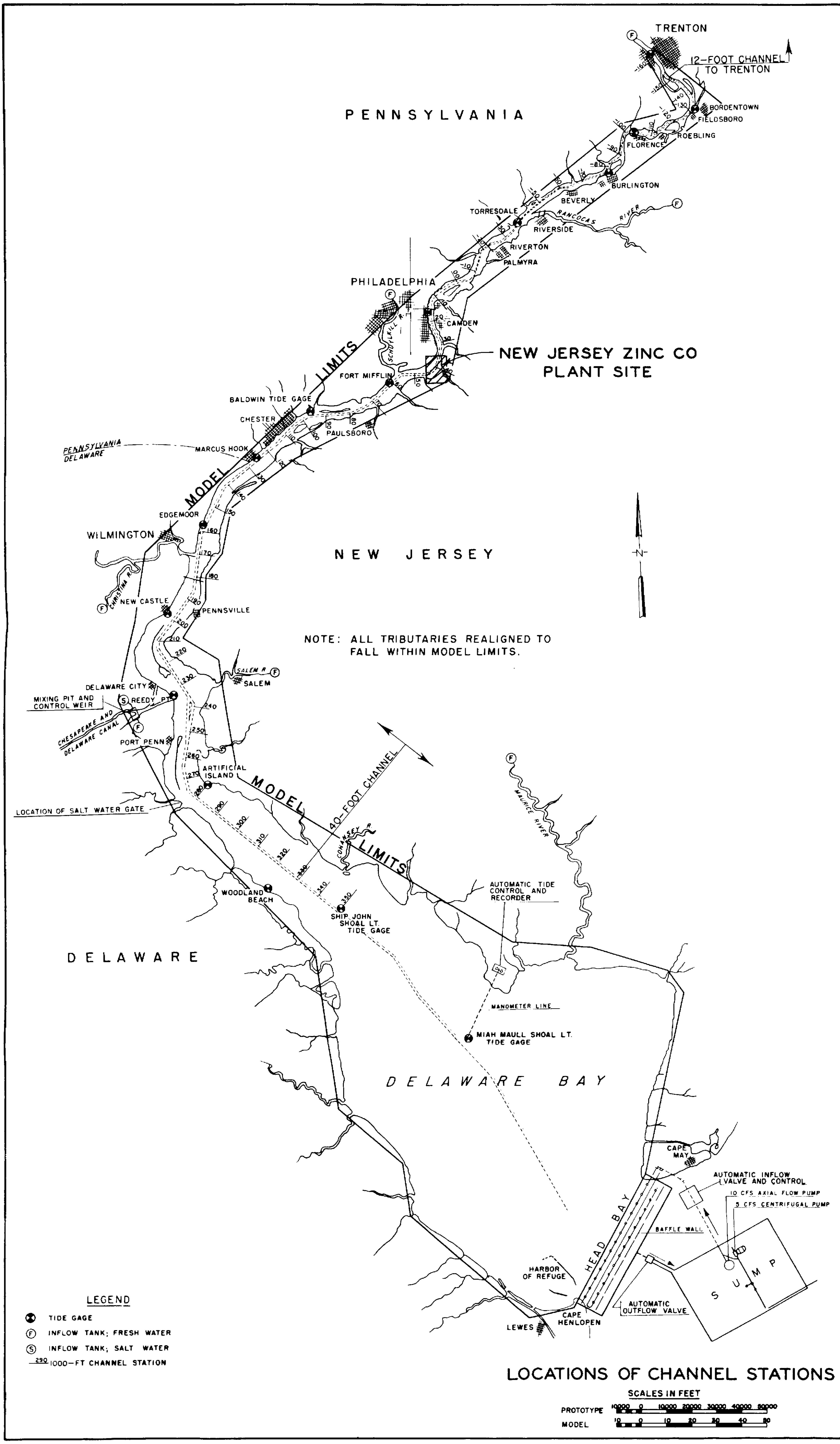
Table 4

Results of Final Local Observations

Dye Concentrations in Per Cent of Plant Effluent Concentration

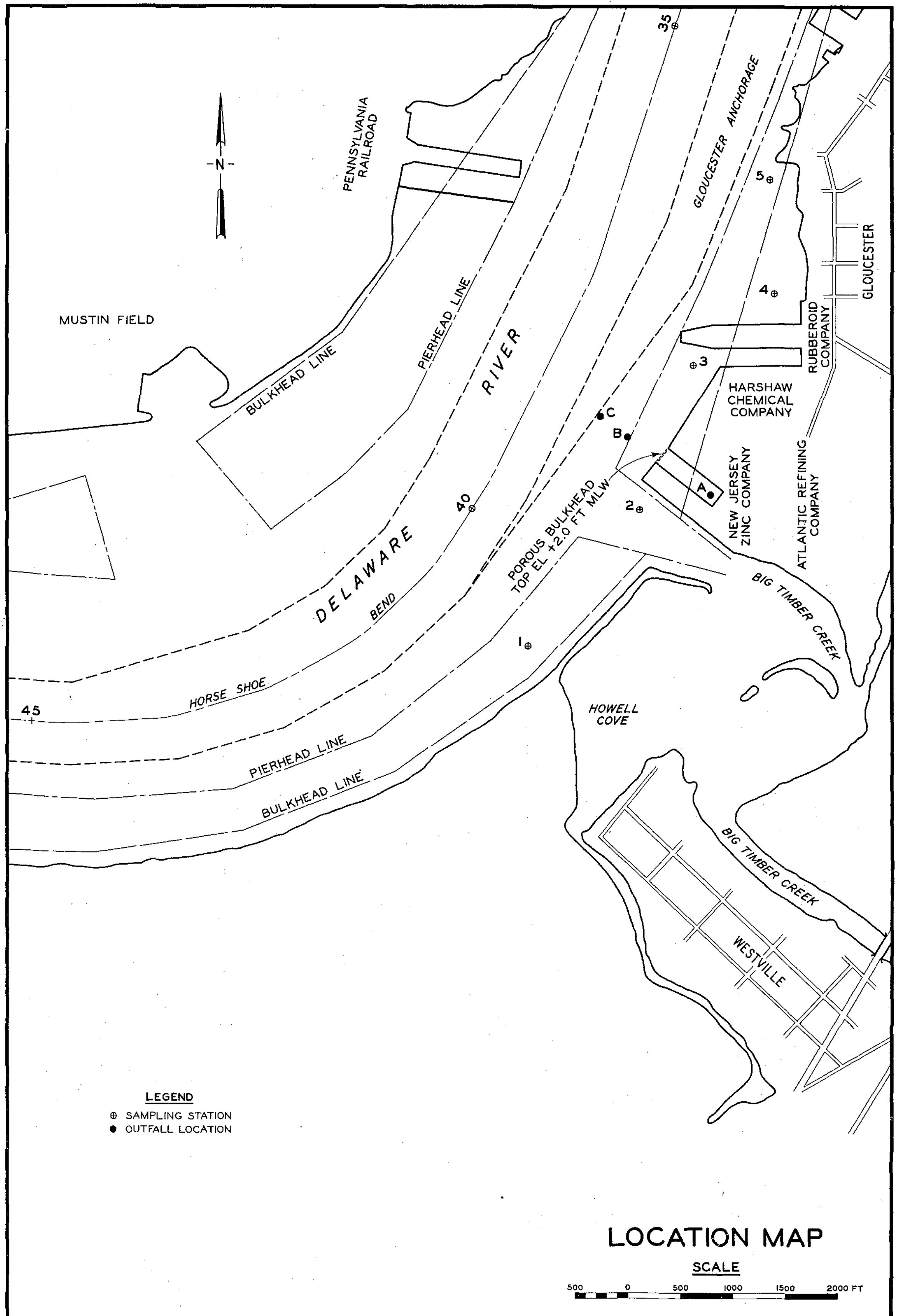
	Tests								
Sta	1	2	3	4	5	6	7	8	9
1	0.036	0.075	0.144	0.189	0.122	0.302	0.248	0.129	0.114
2	0.028	0.099	0.168	0.198	0.165	0.301	0.250	0.163	0.179
3	0.033	0.077	0.161	0.194	0.162	0.294	0.369	0.162	0.244
4	0.019	0.083	0.181	0.207	0.177	0.310	0.290	0.167	0.209
5	0.030	0.084	0.170	0.205	0.178	0.315	0.265	0.180	0.192

Note: See plate 2 for station locations.
Observations were made at time of local high-water slack.



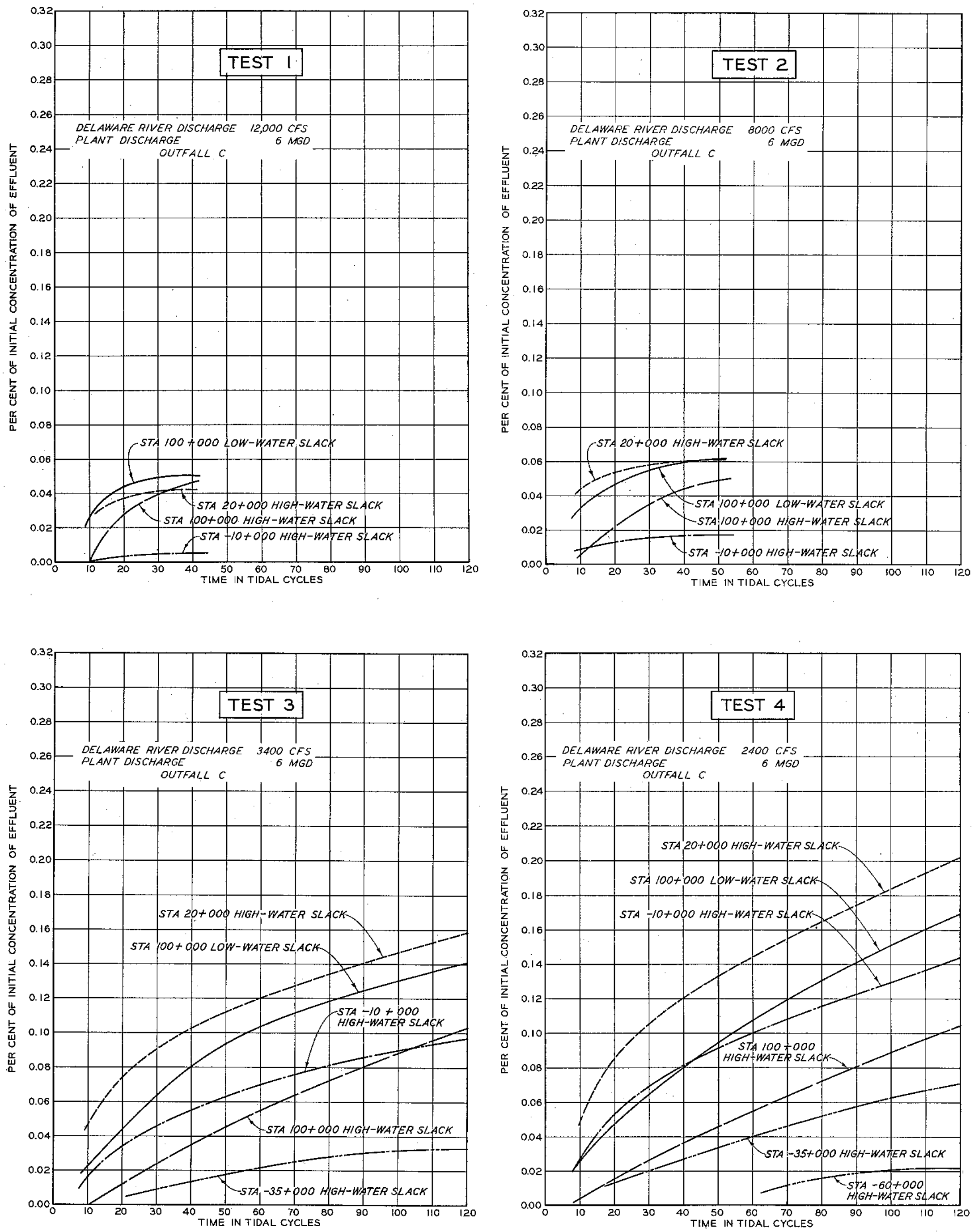
LOCATIONS OF CHANNEL STATIONS

PLATE 1



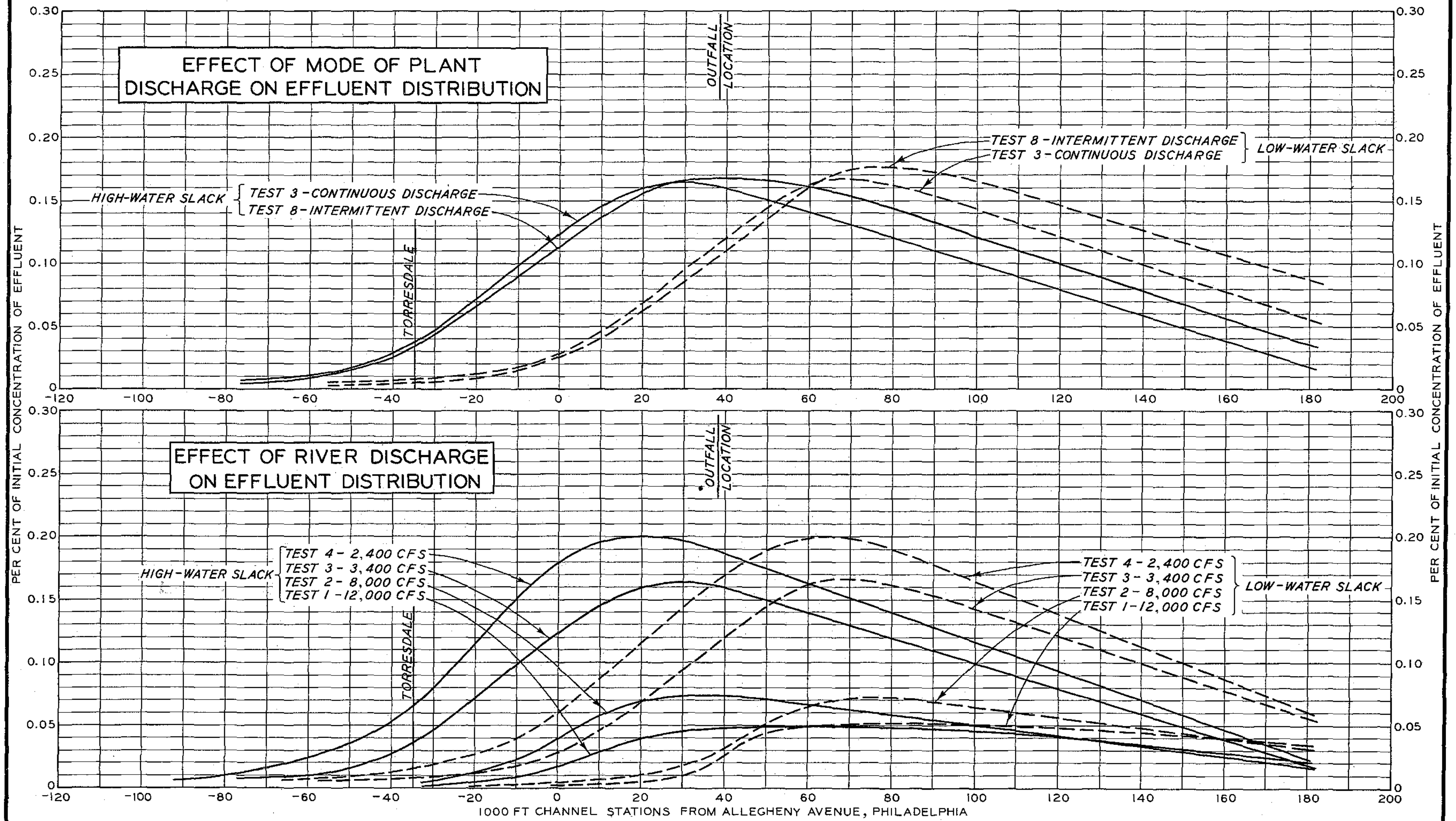
LOCATION MAP

PLATE 2



NOTE: SEE PLATE I FOR LOCATION OF CHANNEL STATIONS.
OBSERVATIONS WERE MADE AT TIME OF LOCAL HIGH- OR LOW-WATER SLACK ALONG CHANNEL CENTER LINE AT APPROXIMATE MIDDEPTH.
DATA FOR THESE CURVES ARE PRESENTED IN TABLE 2.
SEE TABLE I FOR TEST CONDITIONS.

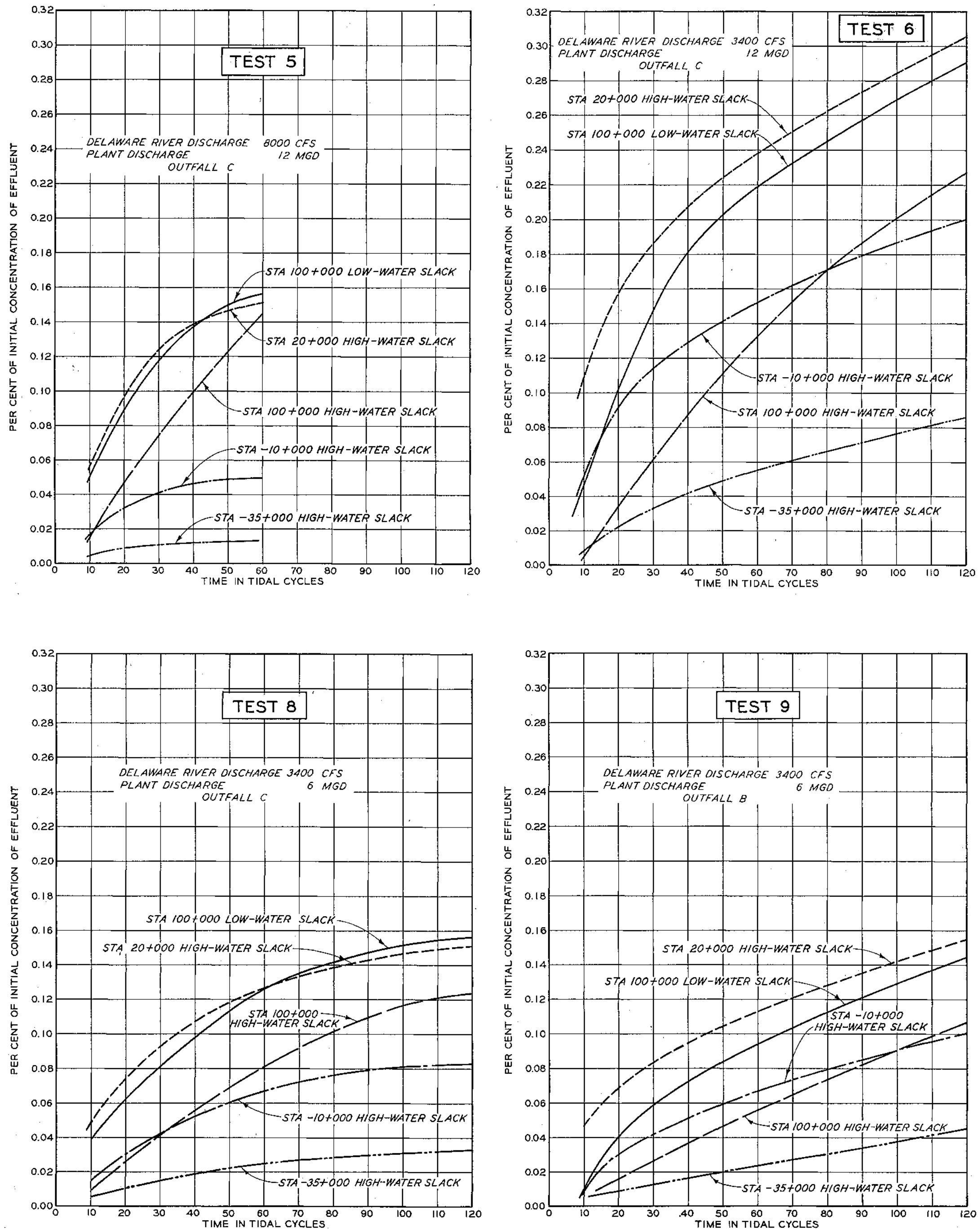
CONTINUOUS OBSERVATIONS
TESTS 1, 2, 3, AND 4



NOTE: SUMMARY OF TEST CONDITIONS SHOWN IN TABLE I.
DATA FOR CURVES ARE PRESENTED IN TABLE 3.
LOCATION OF CHANNEL STATIONS IS SHOWN ON PLATE I AND LOCATION OF OUTFALLS ON PLATE 2.
OBSERVATIONS WERE MADE AT TIME OF LOCAL HIGH OR LOW-WATER SLACK ALONG CHANNEL CENTER LINE AT APPROXIMATE MIDDEPTH.
CURVES PRESENTED ABOVE ARE BASED ON SAMPLES OBTAINED AT 5000-FT INTERVALS UPSTREAM FROM STATION 40+000, AT 10,000-FT INTERVALS BETWEEN STATIONS 40+000 AND 80+000, AND AT GREATER INTERVALS DOWNSTREAM FROM STATION 80+000.

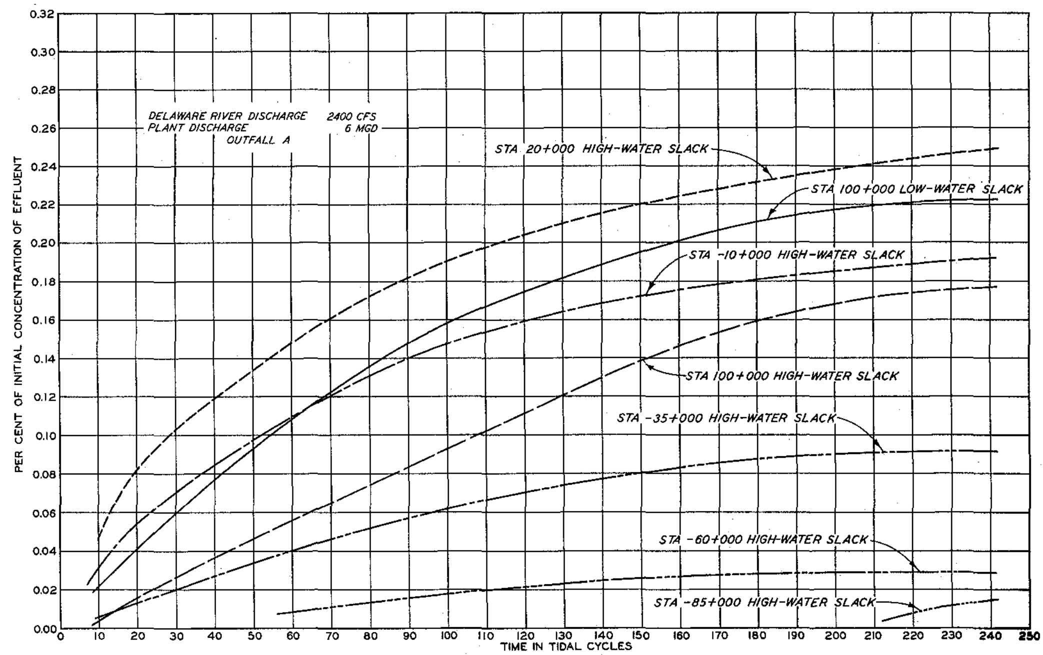
EFFECT OF MODE OF PLANT DISCHARGE AND EFFECT OF RIVER DISCHARGE ON EFFLUENT DISTRIBUTION

PLATE 4



NOTE: SEE PLATE I FOR LOCATION OF CHANNEL STATIONS.
OBSERVATIONS WERE MADE AT TIME OF LOCAL HIGH- OR LOW-WATER SLACK ALONG CHANNEL CENTER LINE AT APPROXIMATE MIDDEPTH.
DATA FOR THESE CURVES ARE PRESENTED IN TABLE 2.
SEE TABLE I FOR TEST CONDITIONS.

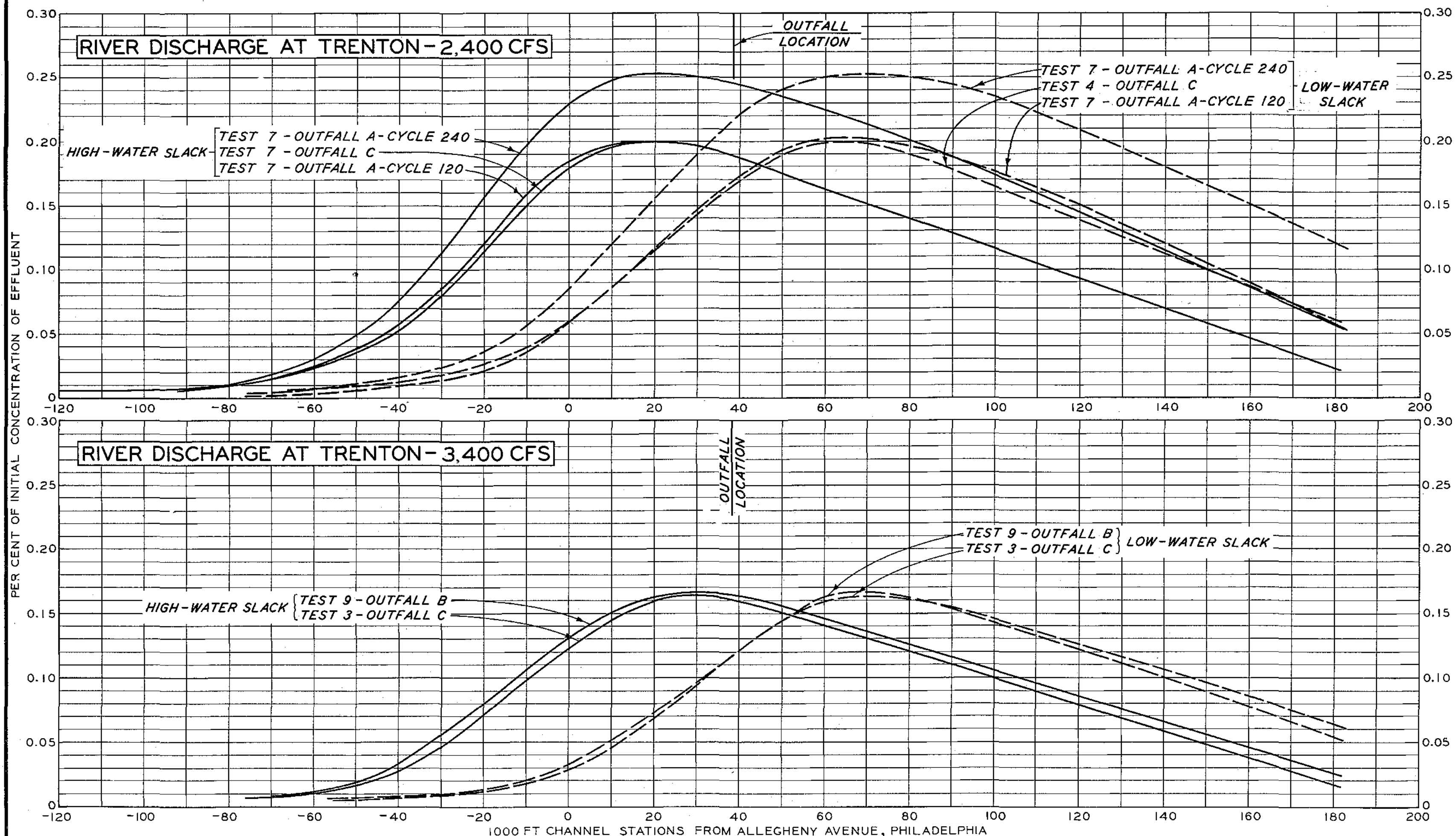
CONTINUOUS OBSERVATIONS
TESTS 5, 6, 8, AND 9



NOTE: SEE PLATE I FOR LOCATION OF CHANNEL STATIONS.
OBSERVATIONS WERE MADE AT TIME OF LOCAL HIGH- OR LOW-WATER SLACK ALONG CHANNEL CENTER LINE AT APPROXIMATE MIDDEPTH.
DATA FOR THESE CURVES ARE PRESENTED IN TABLE 2.
SEE TABLE I FOR TEST CONDITIONS.

CONTINUOUS OBSERVATIONS
TEST 7

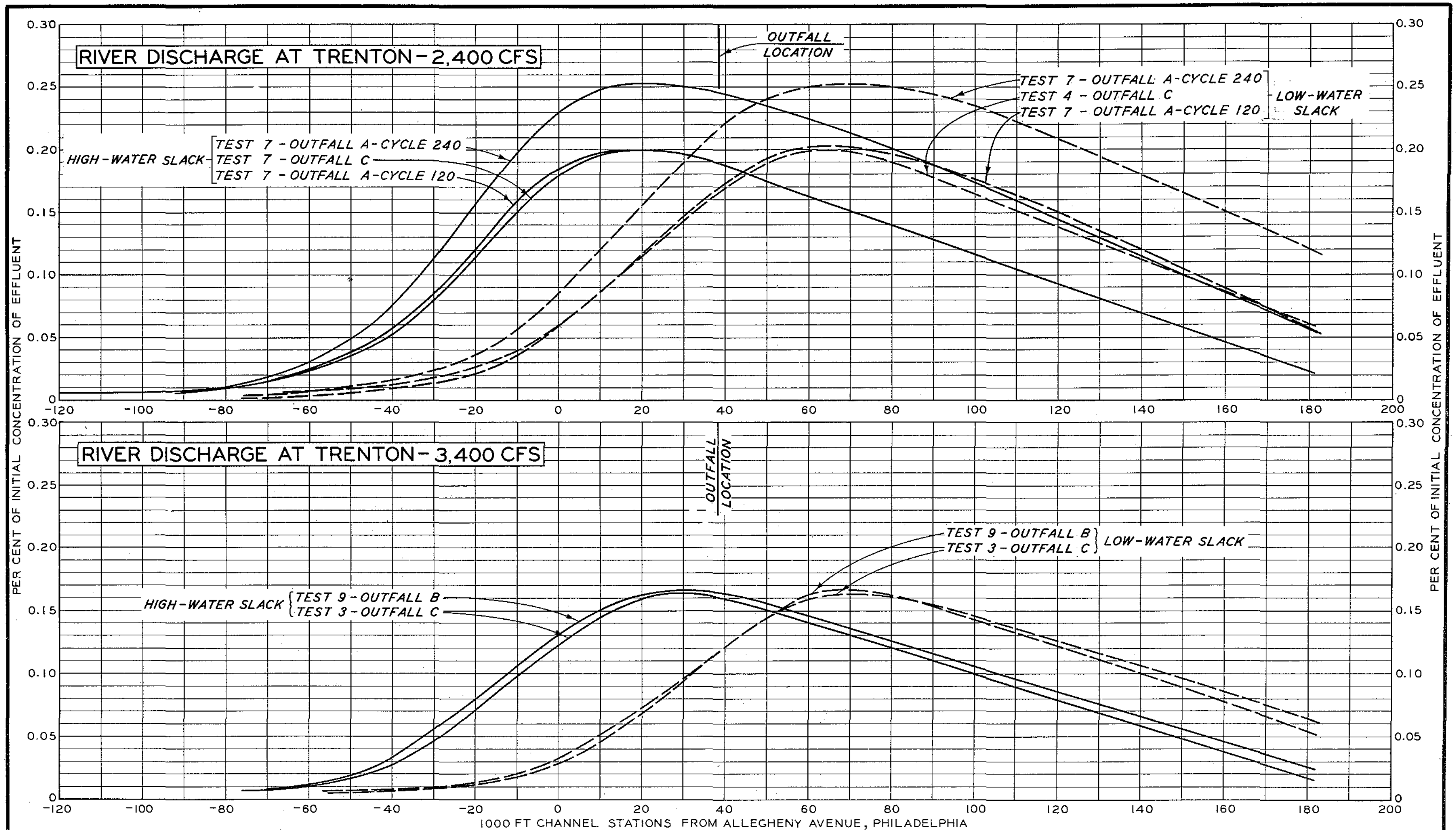
PLATE 7



NOTE: SUMMARY OF TEST CONDITIONS IS SHOWN IN TABLE 1.
DATA FOR THESE CURVES ARE PRESENTED IN TABLE 3.
LOCATION OF CHANNEL STATIONS IS SHOWN ON PLATE 1 AND LOCATION OF OUTFALLS ON PLATE 2.
OBSERVATIONS WERE MADE AT TIME OF LOCAL HIGH OR LOW-WATER SLACK ALONG CHANNEL CENTER LINE AT APPROXIMATE MIDDEPTH.
CURVES PRESENTED ABOVE ARE BASED ON SAMPLES OBTAINED AT 5000-FT INTERVALS UPSTREAM FROM STATION 40+000, AT 10,000-FT INTERVALS BETWEEN STATIONS 40+000 AND 80+000, AND AT GREATER INTERVALS DOWNSTREAM FROM STATION 80+000.

EFFECT OF LOCATION OF OUTFALL ON EFFLUENT DISTRIBUTION

PLATE 7



NOTE: SUMMARY OF TEST CONDITIONS IS SHOWN IN TABLE 1.
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LOCATION OF CHANNEL STATIONS IS SHOWN ON PLATE 1 AND LOCATION OF OUTFALLS ON PLATE 2.
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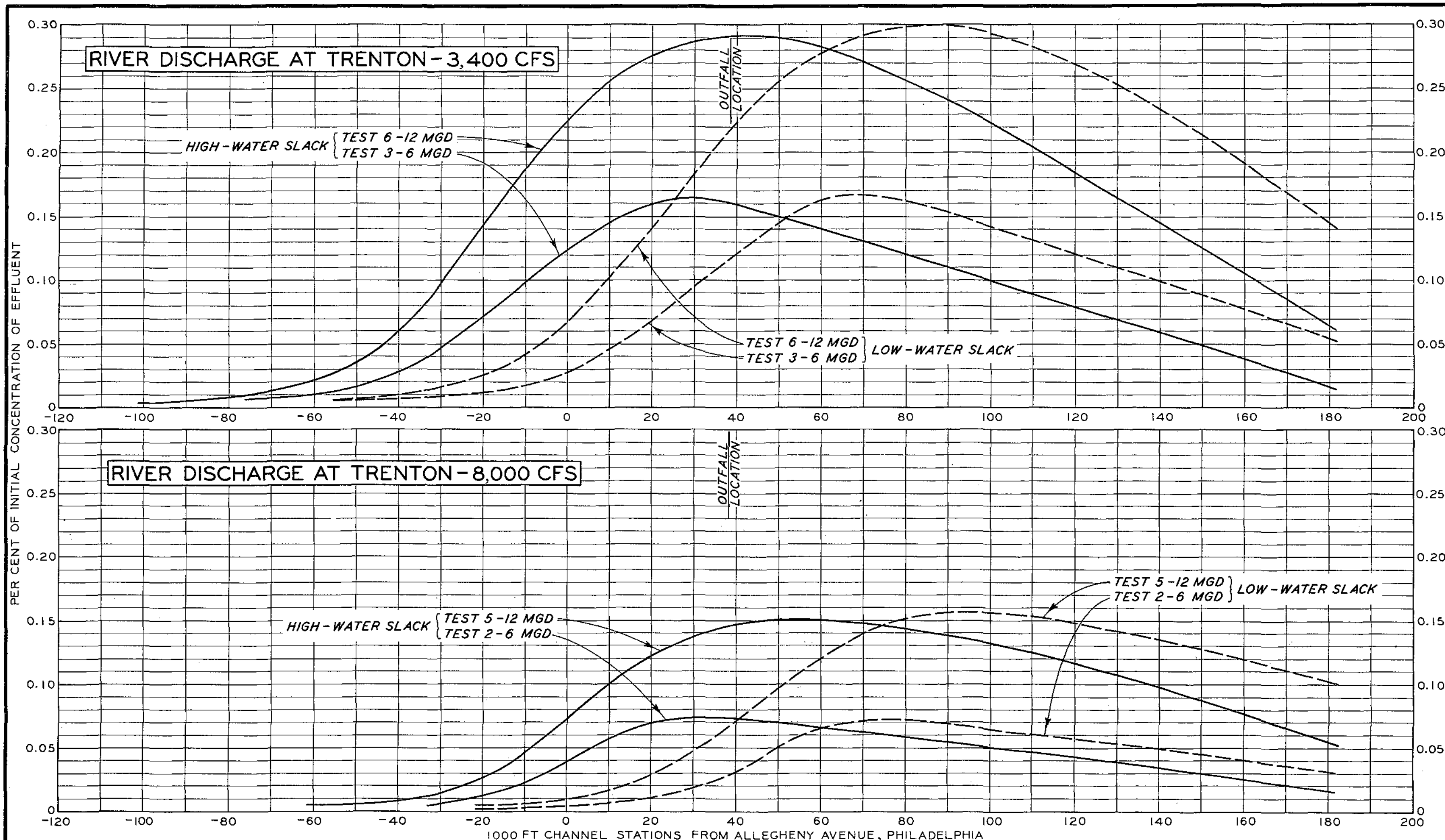
EFFECT OF LOCATION OF OUTFALL ON EFFLUENT DISTRIBUTION



NOTE: SUMMARY OF TEST CONDITIONS SHOWN IN TABLE 1.
DATA FOR CURVES ARE PRESENTED IN TABLE 3.
LOCATION OF CHANNEL STATIONS IS SHOWN ON PLATE 1 AND LOCATION OF OUTFALLS ON PLATE 2.
OBSERVATIONS WERE MADE AT TIME OF LOCAL HIGH OR LOW-WATER SLACK ALONG CHANNEL CENTER LINE AT APPROXIMATE MIDDEPTH.
CURVES PRESENTED ABOVE ARE BASED ON SAMPLES OBTAINED AT 5000-FT INTERVALS UPSTREAM FROM STATION 40+000, AT 10,000-FT INTERVALS BETWEEN STATIONS 40+000 AND 80+000, AND AT GREATER INTERVALS DOWNSTREAM FROM STATION 80+000.

EFFECT OF DOUBLING PLANT DISCHARGE ON EFFLUENT DISTRIBUTION

PLATE 8